UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.

DESIGNS FOR SUSPENDED-LOAD SAMPLERS

based upon

AN EXPERIMENTAL INVESTIGATION OF THE DISTURBANCES
CAUSED BY THE INSTRUMENTS
and
ANALYSIS OF SEDIMENT-LADEN FLOW

J. Pat O'Neill
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PART ONE—INTRODUCTION AND ANALYSIS OF PROBLEM

Introduction

Measurements of soil losses and the determination of the rate of silt transportation by streams have disclosed the need for more efficient apparatus for sampling the suspended load. This equipment is needed especially by the Soil Conservation Service for use when the fundamentals of sediment transportation are being studied or when reliable results are required. Since most of the equipment previously used produces disturbances that affect concentration measurements, more accurate samplers are necessary. Consequently, in this investigation of sampling equipment, experiments which give an indication of the absolute accuracy, rather than a comparison between instruments of unknown accuracy, are made the basis for the practical designs.

Analysis of Problem

Analysis of suspended-load transportation measurements.

The amount of suspended solid material transported by a stream is usually determined by making sediment content and velocity measurements at many points in the cross section and integrating the results. The number of sampling points required will depend upon the degree of accuracy necessary, and, according to O'Brien,[1] upon our knowledge of turbulent flow and its relation to sediment transportation.

The suspended-load samplers used for these measurements may be divided into two classifications, depending upon the length of the sampling period. One might be called the integrating or continuous sampler, and the other the instantaneous or grab sampler. Turbulent fluctuations cause the sediment content at any point in a stream to be continually varying; therefore, only an integrated sample, taken over a period of time long enough to get an average concentration, can truly represent the sediment content. This integration may be made with a continuous sampler of the suction-nozzle type, which maintains the same velocity at the entrance as the

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[1] M. P. O'Brien, Review of the theory of turbulent flow and its relation to sediment-transportation, Trans. Amer. Geophys. Union, April 27-29, 1933, pp. 487-491.

undisturbed velocity of the stream at that point.[2] The mean concentration also may be obtained by combining a number of small grab samples which show the true instantaneous sediment content.

Analysis of sediment-laden flow.

Disturbances caused by the sampler will produce changes in the local concentration that vary with the particle size and distribution. Small changes may be expected when the sediment is fine and uniformly distributed, but larger ones should result when the particles being transported are coarse and the distribution non-uniform. Redistribution of sediment takes place whenever an obstruction causes a stream filament to deviate from its undisturbed path. In the resulting curvilinear flow, materials having a density greater than water will be accelerated less rapidly and will follow a path with larger radius of curvature. When this occurs--that is, when silt and water at any point are following different paths--redistribution is taking place.

Criterion for comparing samplers.

From the above analysis it is apparent that the most representative sample will be obtained when we have the least disturbance to the sampled fluid before it is taken. Therefore, the merits of a

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[2] Continuous suction-nozzle samplers are now being used in the Cooperative Laboratory of the Soil Conservation Service at the California Institute of Technology in studying the fundamental laws of sediment transportation.

sampling device may be judged by the degree to which it meets the conditions set forth in a criterion for the ideal. This requires that no portion of the sampled fluid shall be disturbed by changing its normal velocity, in either magnitude or direction, before it arrives at the point where it is taken. Any sampler will cause some disturbance, therefore, the relative accuracy of such instruments may be evaluated by devising some means of determining the deviation from the ideal.

Other problems in sampling technique.

The measurement of suspended-load transportation makes evident the need for additional research. For instance, methods should be established for determining the minimum number of sampling points in a stream cross section to calculate, with a given degree of accuracy, the quantity of sediment being transported. Likewise, more definite information is needed about the number of grab samples which must be taken at each point.

Obviously these two problems are not independent. Modern theories of turbulence and the methods of statistical analysis will help considerably in solving them. The number of sampling points necessary will be affected materially by the results of research now in progress on the fundamental laws of sediment transportation,[3] while the number of samples necessary at each point should be solved with the aid of accurate grab samplers.

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[3]See footnote on page 3.

PART TWO--HYDRAULIC TESTS

Introduction

It would be a simple matter to determine by direct test the efficiency or reliability of a sampler if the sediment concentration at a point in a stream were known. Unfortunately the only means at hand to determine the concentration involves sampling and at once reduces direct tests to a comparison of instruments and techniques. Furthermore, comparing the sediment caught by various instruments is misleading because the character of both the turbulence and the available sediment in the stream or flume affect the results. The practical difficulty of either directly testing or comparing samplers leads to the consideration of other methods of evaluating the performance of such devices. One method that is believed to give an indication of the absolute accuracy, rather than a comparison between samplers of unknown accuracy, is based upon the preceding flow analysis from which the criterion was developed.

Since the criterion does not permit any disturbance, it becomes necessary to determine the deviation from the ideal; and this can be done by observing the paths of dye streams injected into the flow. Consequently, in the testing procedure, sampler models were supported in a glass-walled flume and dye streams were injected upstream at suitable points for observing the disturbance to the filament of fluid entering the sampling space. It seems logical to conclude that there will be no redistribution of sediment if the dye streams, which follow the flow perfectly, show that no disturbance occurs.

Selection of samplers for testing.

After studying various samplers and considering our immediate needs, two types of grab samplers were selected for hydraulic tests because they seemed most promising for development into instruments that produce little disturbance. One, the horizontal-tube type, consists of a cylindrical or prismatic tube that can be closed to trap a portion of the fluid. The other, the cutter-type sampler, traps a cylinder of fluid between two sealing disks when a spring-actuated cutter tube slides over one disk and strikes the other. The latter type was first used by the late Henry M. Eakin[4] in studying suspended load in the Mississippi.

Hydraulic Tests of the Eakin Cutter-type Sampler

Figure 1 shows one unit of the original Eakin cutter-type suspended-load sampler. A comparison of this sampler with many others indicates that it would cause less disturbance to the flow of the sampled fluid and thereby more nearly satisfy the criterion for

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[4]Henry M. Eakin, Diversity of current-direction and load-distribution on stream-bends, Trans. Amer. Geophys. Union, April 25-26, 1935, pp. 467-472.

the ideal. Those types that do not allow free and undisturbed circulation through the sampling space cannot comply with the criterion.

Figure 2 shows some of the hydraulic models and a view looking down into the flume where they were tested in 9 inches of water which had a velocity of about three-quarters of a foot per second. The milk bottle above the observation window supplied the dye that was injected through a small tube at points located directly upstream from the center line of the models and at vertical intervals of one-quarter of an inch. In the foreground one of the sampler models is shown in place ready for a test in which the paths of the dye streams, as seen from the flume window, were drawn in relation to the sampler models.

It was evident from a flow analysis that the interference caused by the original Eakin sampler (fig. 1) could be greatly reduced by removing the trip cord, eliminating the one-quarter-inch recess at the top of the sampling space, using a thin cutter tube, and removing the rod from the center of the sampling space by supporting the mechanism from the rear with a streamlined housing. A wooden model (fig. 2-C) with outside dimensions conforming to these changes was used in the first run. A study of the resulting flow pattern (fig. 3) indicated that the high-pressure area in front of the body caused the flow to curve toward the gap where the sampling space was located. This could be partly prevented by isolating the body sections from the sampling space with thin plates extending upstream

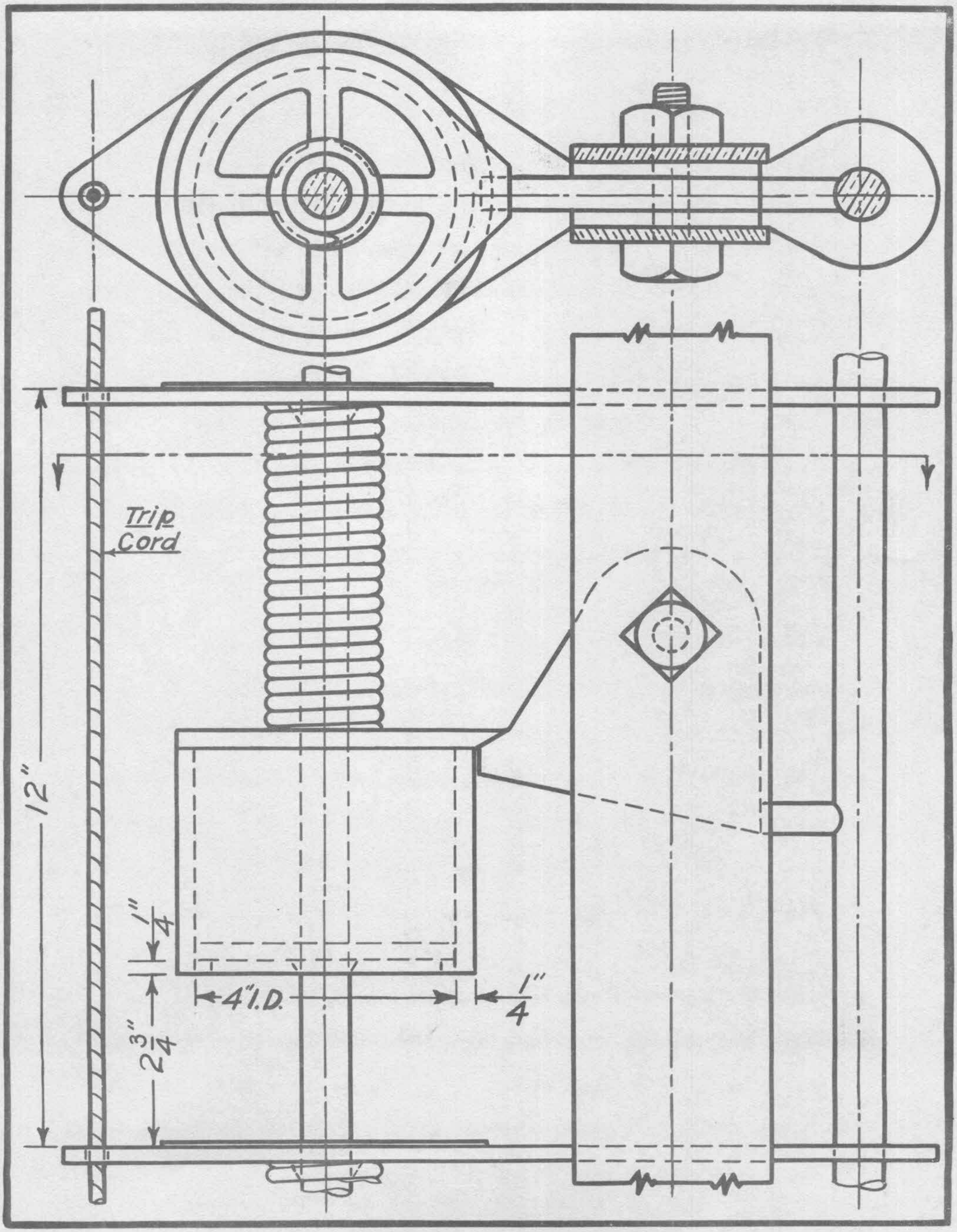


Figure 1.-The original Eakin cutter-type suspended-load sampler.

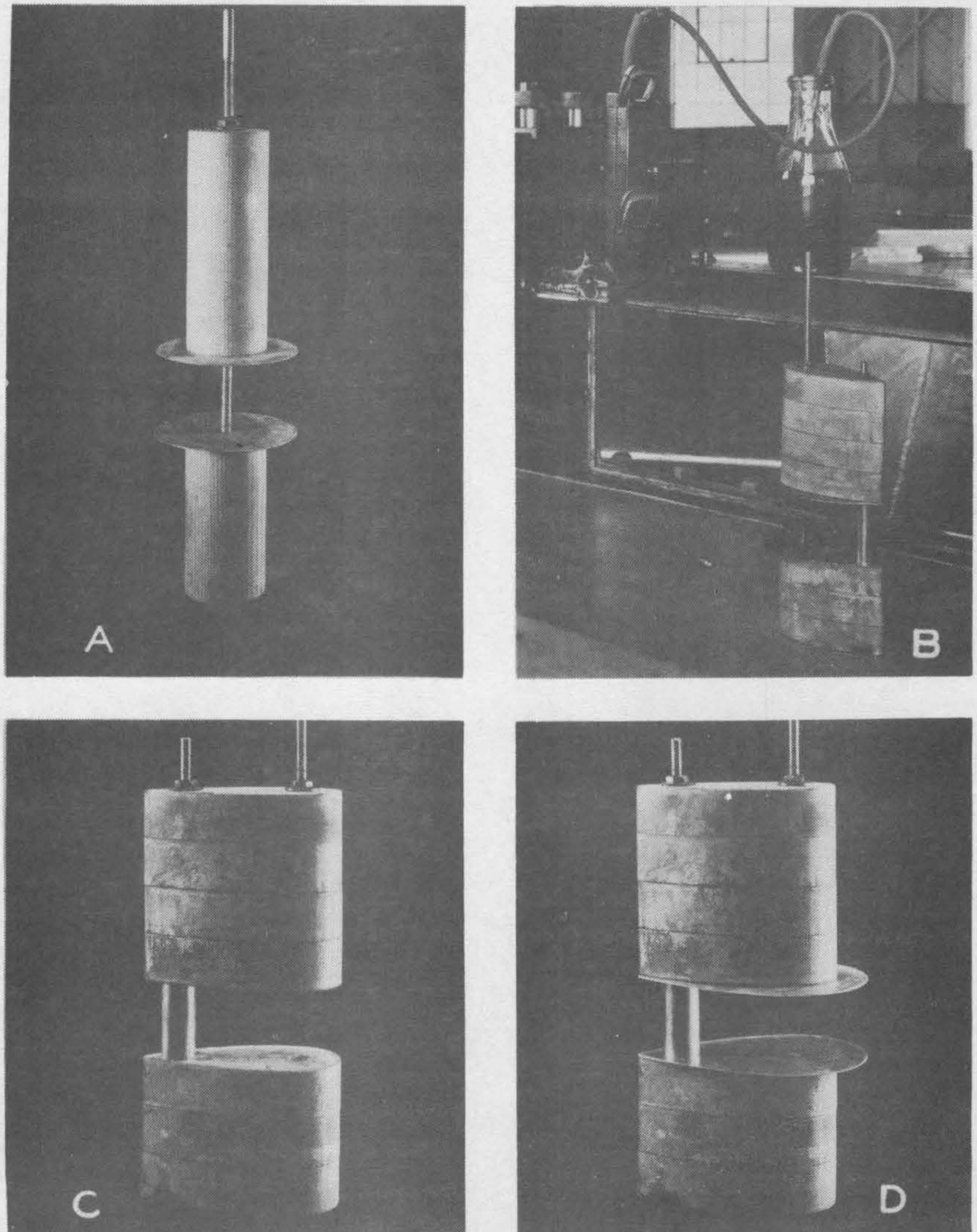


Figure 2.--Equipment for testing cutter-type samplers.

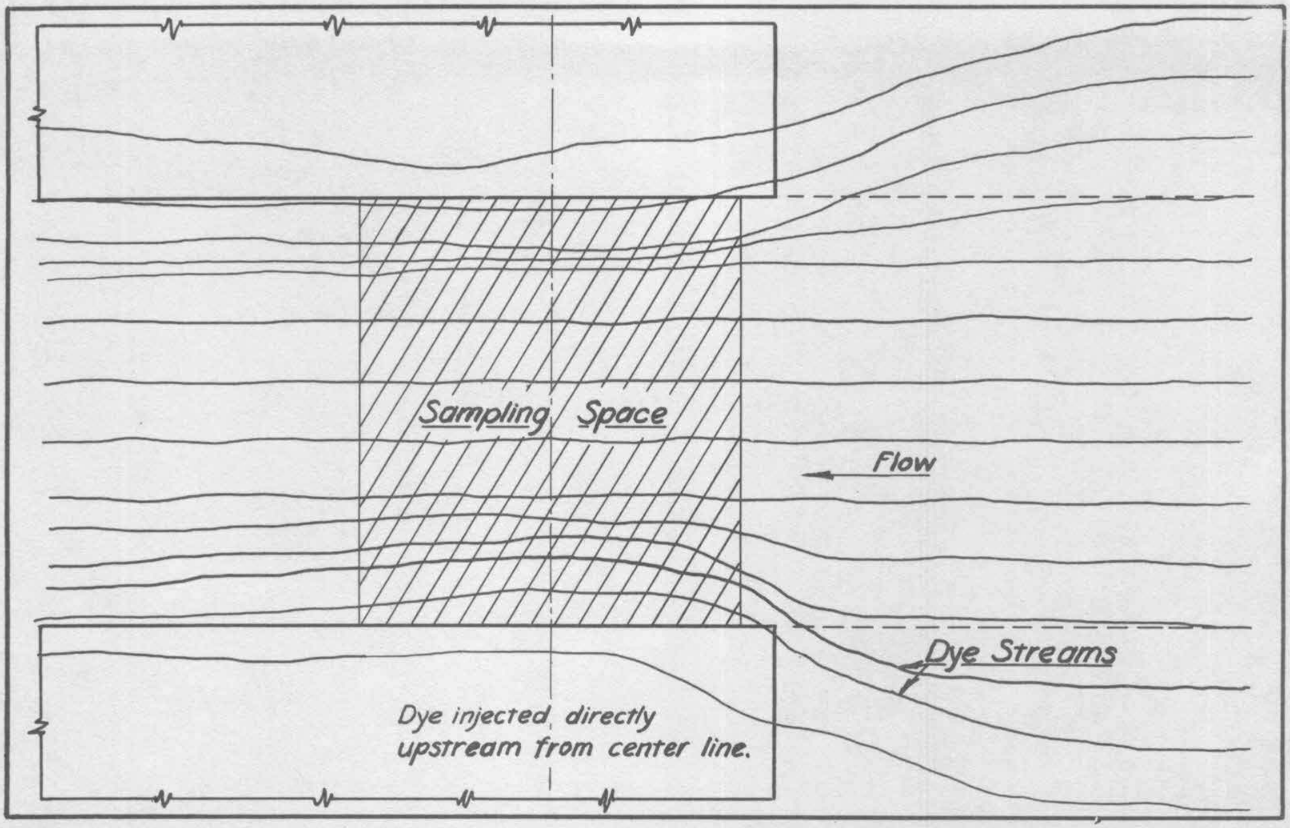


Figure 3.—Plot of stream lines showing curved flow caused by the sampler body.

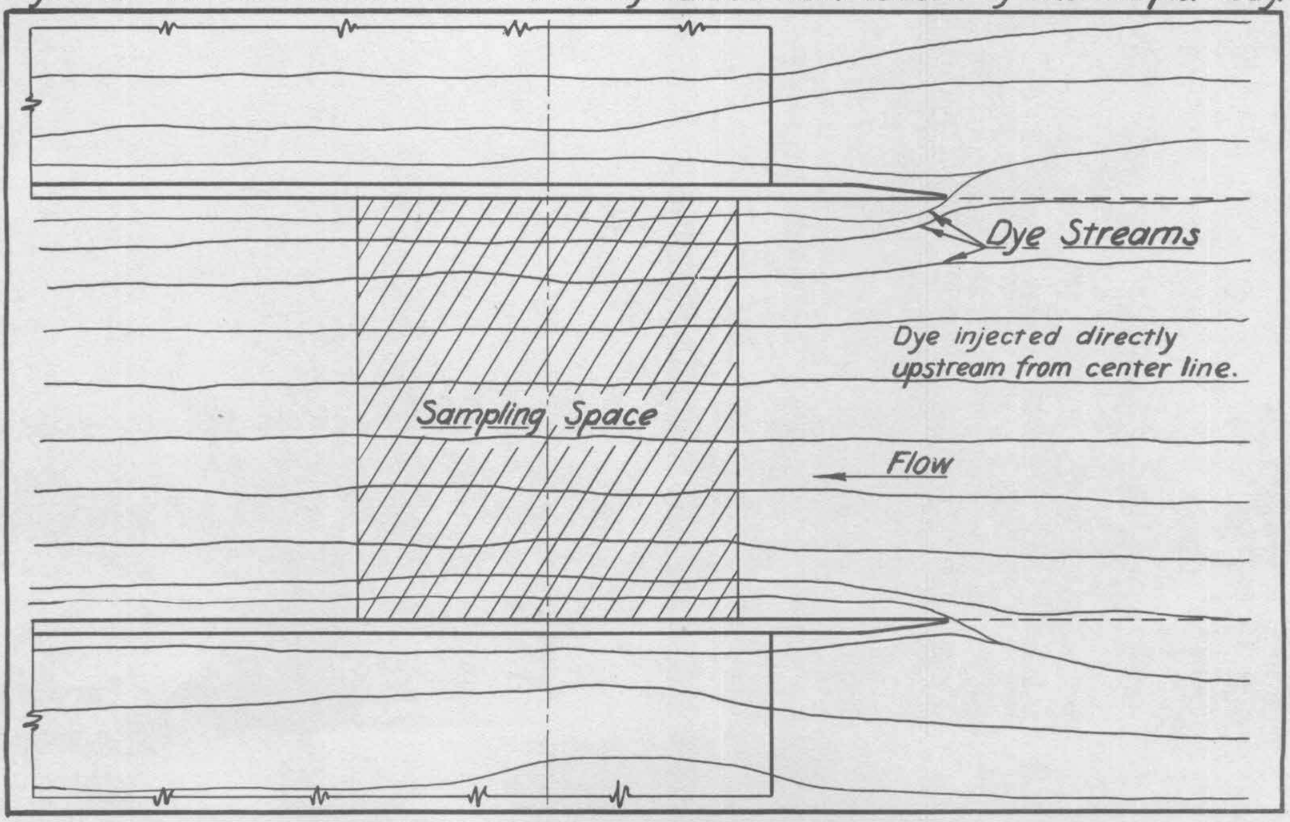


Figure 4.—Stream-line plot showing plates for decreasing curvature of flow.

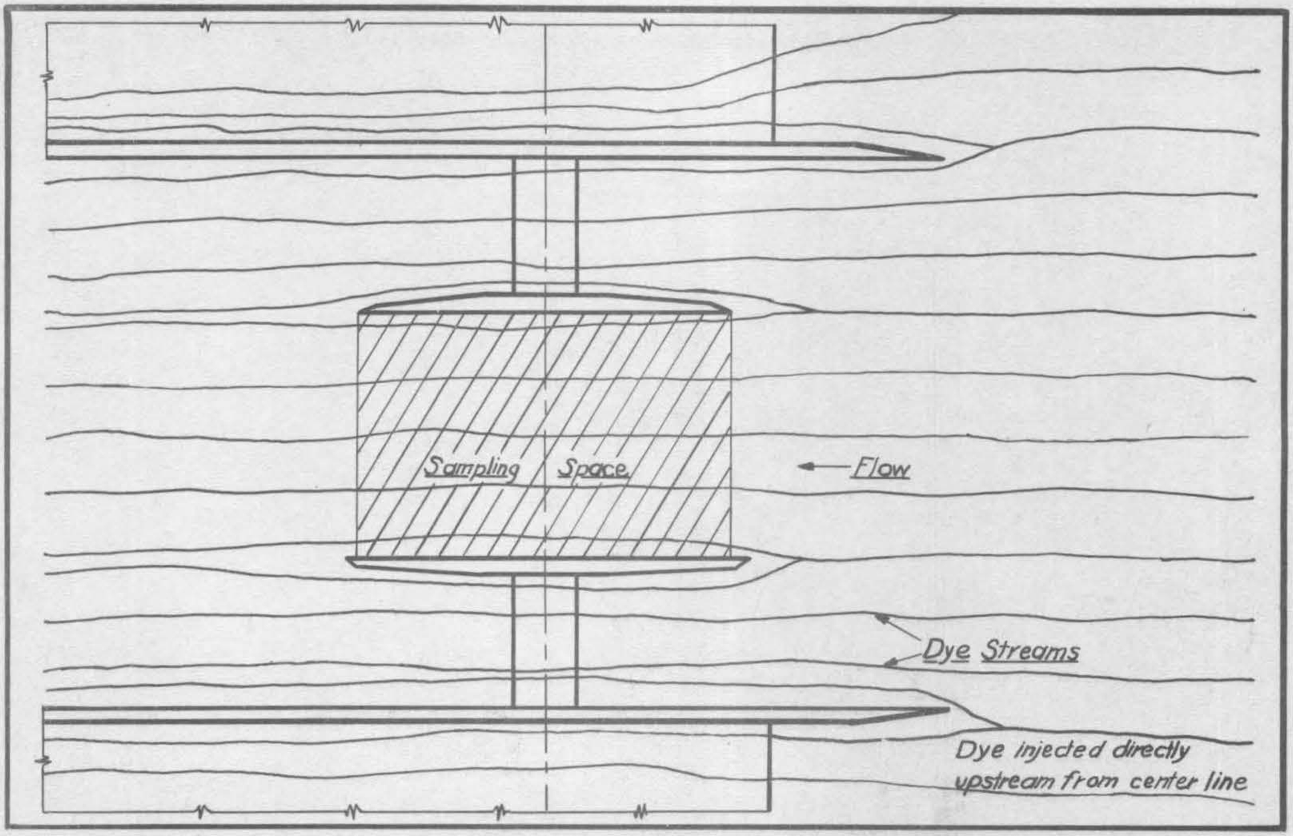


Figure 5.- Stream-line plot showing plates and disks for decreasing curvature of flow.

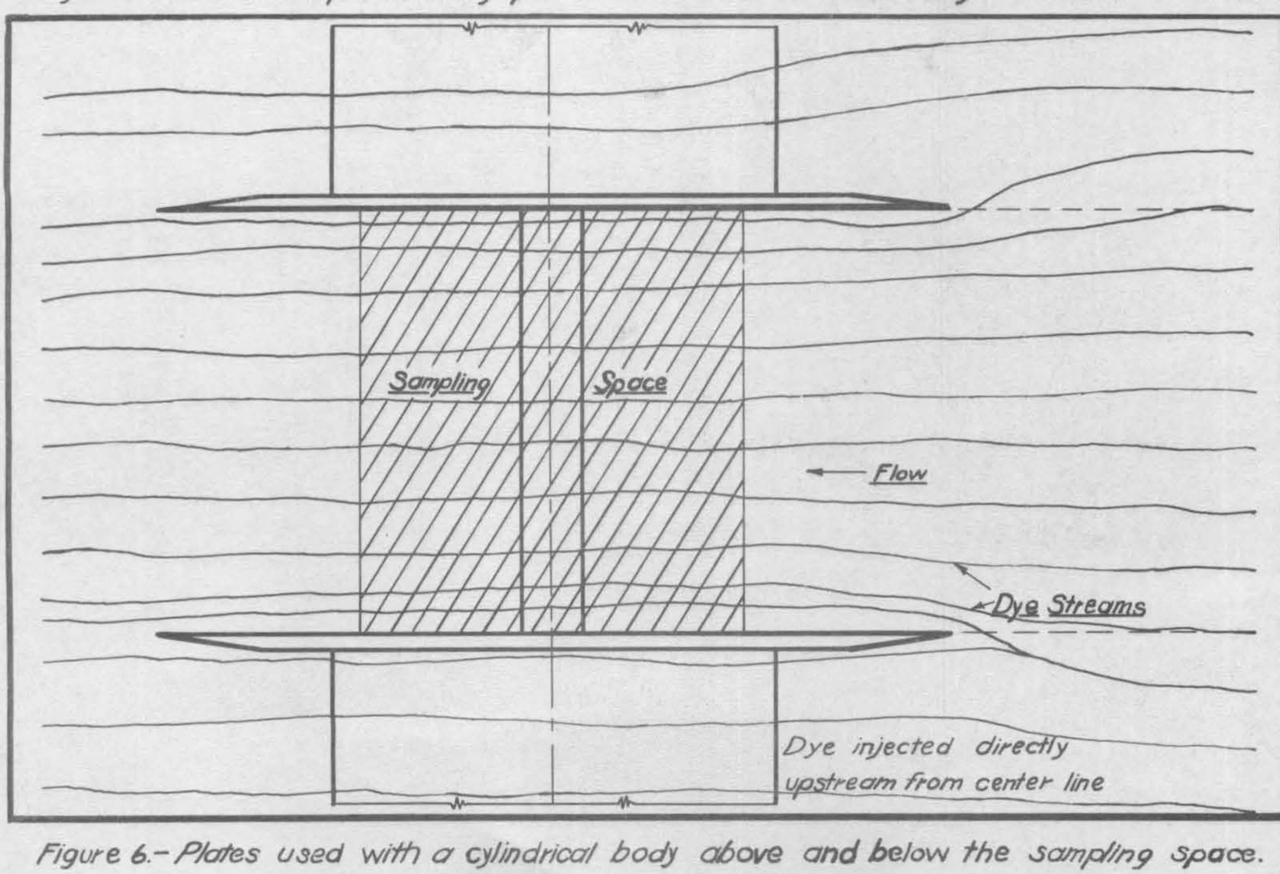


Figure 6.- Plates used with a cylindrical body above and below the sampling space.

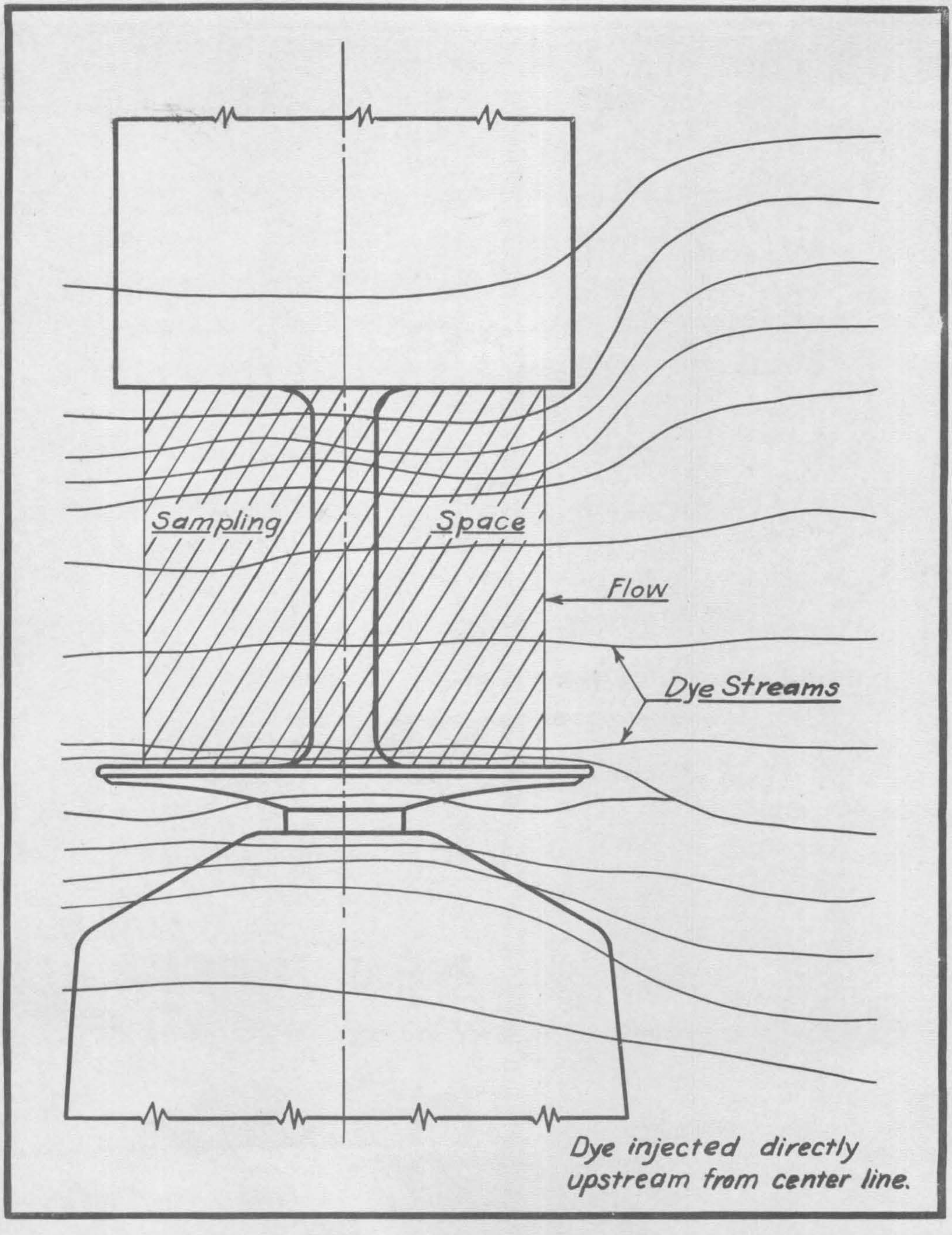


Figure 7.- Plot of stream lines for the Eakin sampler model 3530-B.

and to the sides as shown in figure 2-D. The flow pattern for a model with this modification (fig. 4) may be compared with figure 3 to show the resulting improvement. Further flow tests were made to investigate the proper width and shape of the plates.

A study of these flow pictures suggested the possibility of sampling only the least disturbed part by isolating it between thin disks (fig. 2-B). Although a slight improvement resulted, as may be seen by comparing figures 4 and 5, this was not considered sufficient to warrant the use of the more complicated construction.

Figures 6 and 7 show streamline plots for cylindrical-body samplers which have a rod through the sampling space. The former shows the effect of using circular plates to separate the body from the sampling space while the latter is a flow pattern for one of the single-unit line-suspended samplers which was developed in this laboratory. Flow-correcting plates were not used on the line-suspended sampler because it would drift and assume an angle to the flow so that their advantages could not be fully realized. The drift angle is determined by the velocity of the stream and, as explained in part four of this report, by the design of the instrument. It should not be concluded, however, that tilting the sampler has sacrificed the advantages of the cutter-type construction; because, with bad orientation, the flow was not impaired to the extent that it would be in other types that have a sampling space less accessible to the flow.

Hydraulic Tests of the Horizontal-tube Sampler

The other grab samplers that were tested with hydraulic models were of the horizontal-tube type. Instruments of this kind have been used that employed gate valves or standard check valves at the end of 1-inch to 1 1/4-inch-diameter pipe, the valves being spaced 12 to 14 inches apart. The internal resistance of a long, slender tube made it impossible for the flow conditions to be unchanged as water passed through it. The lower velocity inside the tube may cause deposition of the coarse particles, and the change in velocity at the entrance will cause some sort of redistribution of the sediment. Because of such undesirable flow conditions, samplers using long, slender tubes were not considered satisfactory and consequently they were not tested.

A shutter mechanism consisting of a plug valve, which traps a portion of water inside the plug (fig. 8), would permit the use of a short tube with a large diameter. Horizontal tubes of this sort could be placed, one above another, at the desired intervals to form a multiple-unit sampler. With the tube-supporting member the same size as the plug-valve housing, the tendency would be for more than the normal amount of water to be forced through the tube. The internal friction of the tube would oppose this tendency, however, and could be made to balance it exactly by adjusting the tube length.

The position and length of the tubes could be varied in the hydraulic models shown in figure 9. In the testing procedure a single dye injector was supported 2 1/2 inches upstream from the entrance of the tube (fig. 9-A), and the injector adjusted vertically and across the flume until the dye stream was split by the wall of the tube, one-half going inside and one-half outside. A number of points where the dye stream split were found and located with respect to the axis of the tube. Plots of these readings gave the cross-sectional area, 2 1/2 inches upstream from the sampler, of the stream filament entering the tube. Changes were made in the sampler design in order to make the cross section of the stream filament equal to the cross sectional area of the tube.

In the first series of tests a 2 1/2-inch-I. D. tube was mounted in a 4 1/4-inch cylindrical body (fig. 9-B) and also in a 4 1/4 x 9-inch streamlined body (fig. 9-C). The nose length was kept constant at 2 inches while the total tube length was varied from 11 to 15 inches. The cross sections of the stream filaments which entered the tube are plotted and compared in figure 10. In the plot of filament area for various tube lengths it is shown that, due to some instability that existed for long tubes, changing the length between these limits did not produce a progressively decreasing filament area. Two repeat runs are shown to indicate the accuracy of the tests at a velocity of 1 1/3 feet per second. Higher velocities were not used because, in the repeat run made at 2 feet per second, it was difficult to trace accurately the path of the dye. The slight change in filament cross section was probably due

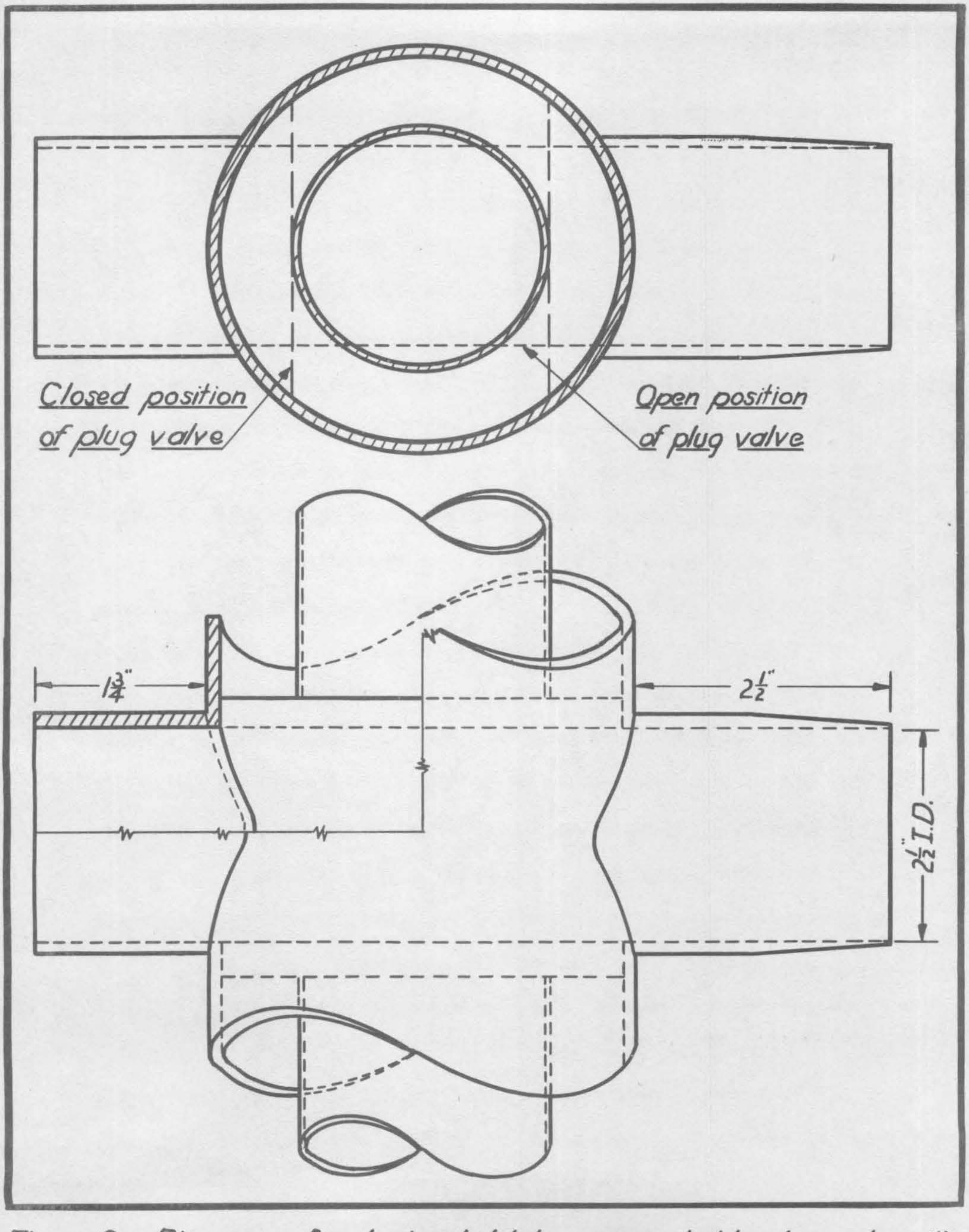


Figure 8.—Diagram of a horizontal-tube suspended-load sampler with a plug-valve shutter

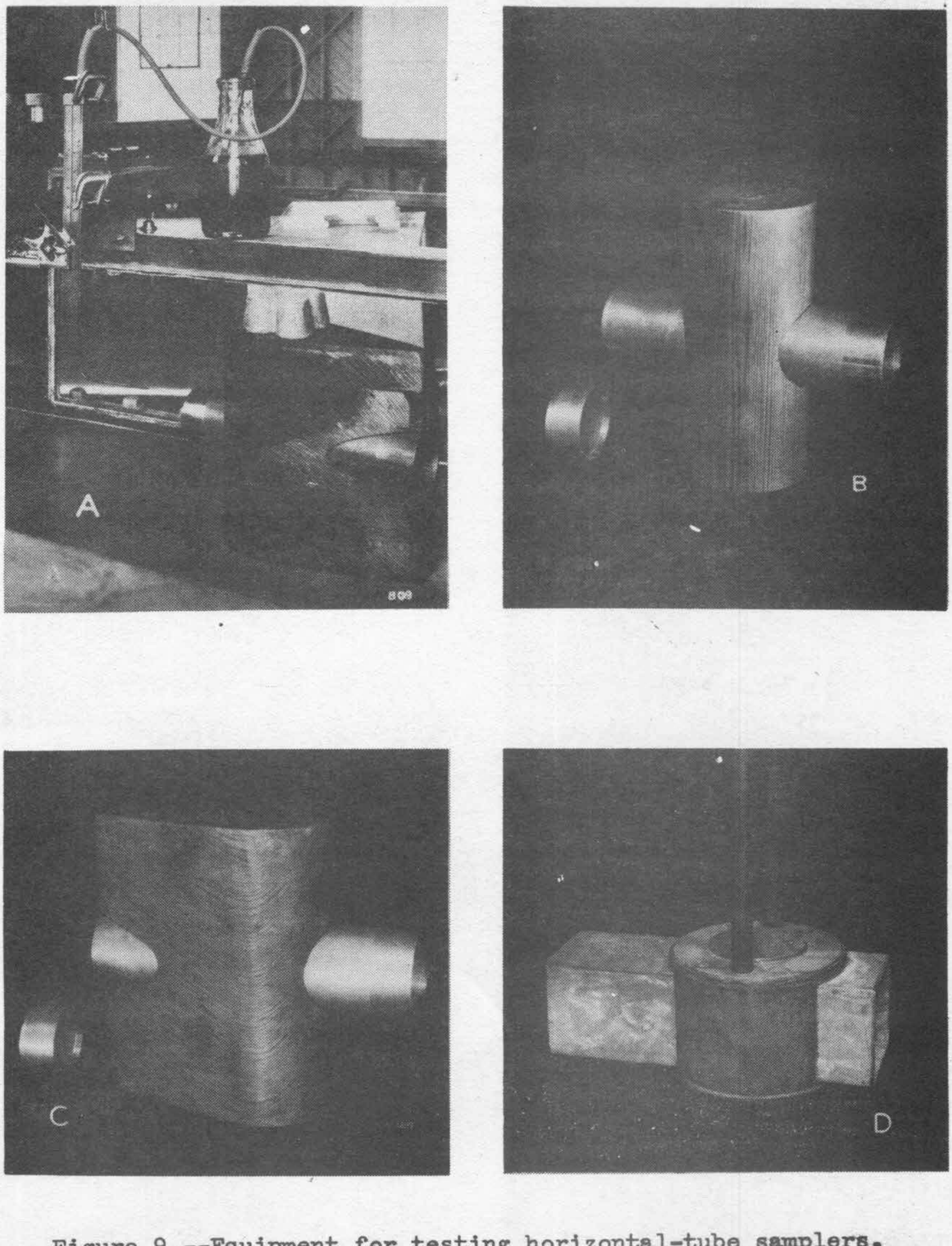


Figure 9.--Equipment for testing horizontal-tube samplers.

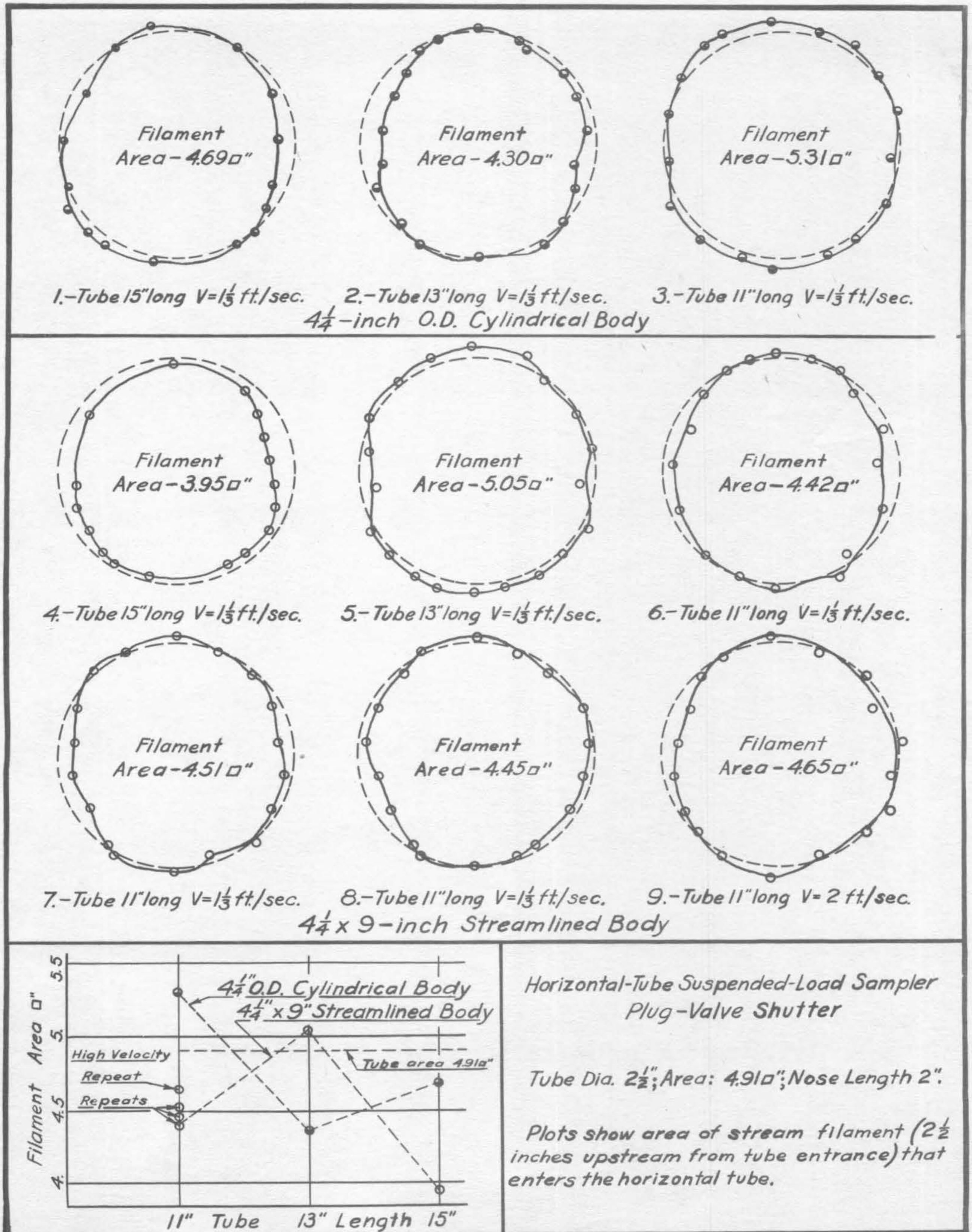


Figure 10.-Plots showing stream-filament cross-sections which enter horizontal-tube samplers. The tail length is varied and the area recorded.

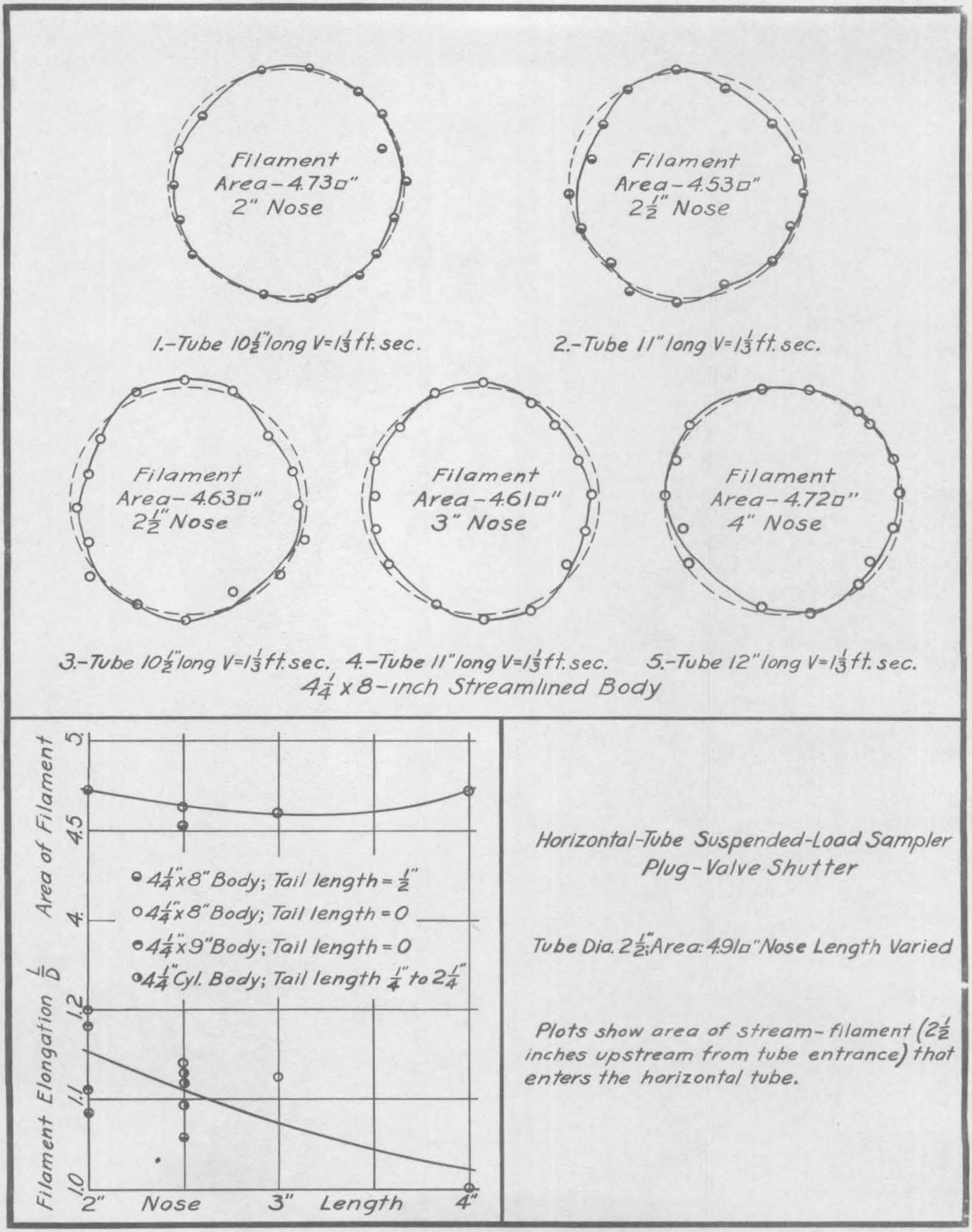


Figure 11.-Plots showing stream-filament cross-sections which enter horizontal-tube samplers. The nose length is varied and the area and elongation recorded.

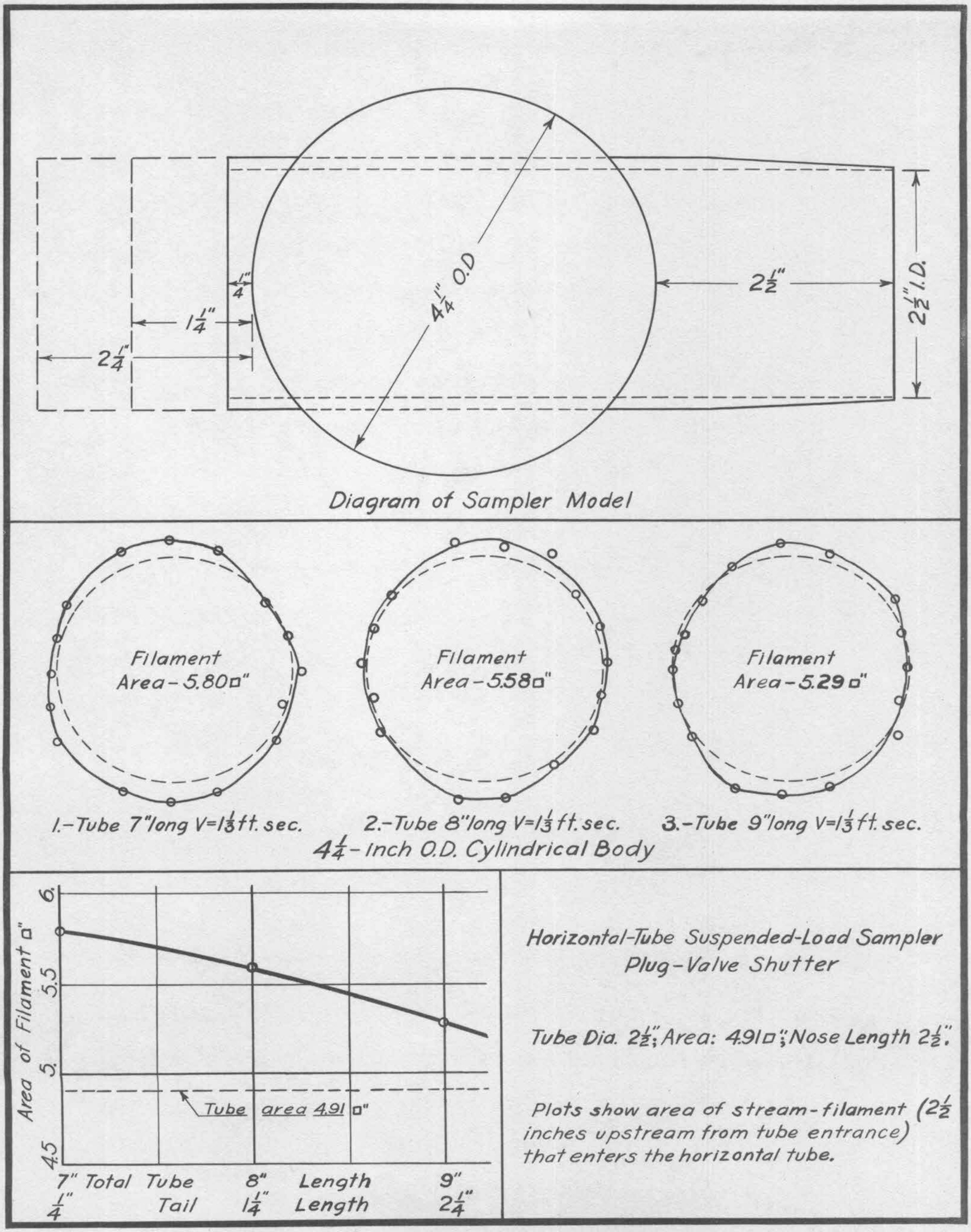


Figure 12.-Plots showing stream-filament cross-sections which enter the cylindrical-body horizontal-tube sampler. The tail length is varied and the area recorded.

to this difficulty, although it might be attributed to changes in the shape of the turbulent wake at different velocities.

In this run, all the filament-area plots are elongated because the body affects the entrance conditions. This, together with the fact that too long a tube was required for the proper filament area, led to tests on models with longer nose lengths. Before making a new set of runs, however, the streamlined body was cut down to a length of 8 inches in order to investigate the possibility of getting the proper conditions without a tail extension.

In figure 11, where the effect of variations of the nose length is recorded, it is shown that such variations alone, over the practical range, have little effect on the filament area. However, in the plot of filament elongation for various nose lengths, it is shown that there is less elongation when the entrance is farther from the body; consequently, a nose length of one tube diameter was used for the final run in which the shorter streamlined body was not used because the alteration did not produce the correct filament area.

The final run with this set of models was made with the 2 1/2-inch-I. D. tube in the 4 1/4-inch cylindrical body. The nose length was adjusted to one tube diameter and the tail length was varied by using tube extensions to produce changes in the filament area. The results are recorded in figure 12 and indicate that the filament area decreases with increasing tube length. By extrapolation it appears that a tail length of about 3 1/4 inches would give a filament with an area equal to that of the tube cross section. However, a longer nose length might be better since it would put the entrance farther from the disturbed area and reduce the required total tube length. Before horizontal-tube samplers are constructed, more detailed investigations along these lines should be conducted, using the exact dimensions of the proposed designs.

In the above tests the body sections between the horizontal tubes had the same size as the plug-valve-shutter housing in order to provide sufficient stiffness for a stack of samplers held rigidly at one end. If a body section only long enough to enclose the shutter mechanism is employed, the smaller size will reduce the high-pressure area in front of the body and the low-pressure area behind it. This will make it possible to use shorter tube extensions and thus produce a sampler that causes less disturbance to the normal flow. A rotary, barrel-type shutter might be used to avoid possible objections to rotating the alignment of the sampling space, as is done in closing the plug-valve sampler; and a square tube could be used in order to secure the largest sample possible in relation to the size of the shutter housing. These changes would result in a design similar to figure 9-D. Tests of this model showed that the plot of the stream-filament cross section had an area smaller than that of the tube. This indicated that the tube extensions could be made much shorter and possibly the rear extension could be eliminated. Due to the anticipated difficulty in producing a sampler of this type that would operate satisfactorily in silt-laden water, further tests were not conducted.

Summary of Results and Conclusions on Hydraulic Tests

Criterion developed for comparing samplers.

A careful analysis of sediment-laden flow has supplied the basis for a criterion for an ideal sampler which requires that no portion of the sampled fluid shall be disturbed by changing its normal velocity, in either magnitude or direction, before it arrives at the point where it is taken. By devising means of determining the deviation from the ideal it was possible to evaluate the performance of sampling devices and to develop improved designs.

Hydraulic-model tests indicate deviation from criterion.

The original Eakin cutter-type sampler (fig. 1) was modified in order that it might comply more closely with the criterion for an ideal sampler. Plots of the flow around various models (figs. 3, 4, and 5) indicated the relative amount of disturbance to the sampled fluid. These flow patterns show that thin plates separating the body section from the sampling section improve the flow conditions materially. An additional slight improvement results when only the central portion between the plates is trapped between thin disks.

Flow plots for models which have a cylindrical body and a rod through the sampling space are shown in figures 6 and 7. Although the flow conditions represented by figure 6 are better, the plates were not used on the line-suspended sampler (fig. 7) because it will drift and assume an angle to the flow so that the advantages of the plates cannot be fully realized.

A satisfactory horizontal-tube sampler can be constructed by making adjustments so that fluid will have no more difficulty in going through the tube than around it. This may be accomplished if the sampling space has a length between one and two times the tube diameter. The high-pressure area before, and the low-pressure area behind the body of the sampler have a tendency to produce excess flow through the sampling section. However, the worst of the high-pressure area which causes curved flow in front of the body may be avoided by extending the tube entrance upstream about three-fourths the body diameter, and the remaining tendency toward excess flow through the tube may be overcome by using the proper tail length.

Conclusions on hydraulic tests.

Experiments have shown that satisfactory samplers may be built of both the cutter type and horizontal-tube type, provided design principles based upon properly conducted flow studies are observed. After making an analysis of sediment-laden flow and studying the results of flow-pattern investigations, it was concluded that the Eakin cutter-type sampler could be made to approach more closely the conditions set forth in the criterion for the ideal, and therefore it was selected for the development of improved mechanical designs.

PART THREE—THE DESIGN OF MULTIPLE-UNIT EAKIN CUTTER-TYPE SUSPENDED-LOAD SAMPLERS

Designs Considered

The need of the Soil Conservation Service for an instrument designed to take simultaneous samples at vertical intervals of one foot or more brought about the development of the apparatus described below. It has been shown by flow-pattern investigations that a relatively undisturbed sample may be obtained with the Eakin cutter-type sampler when thin plates are used to separate the flow around the body from the flow through the sampling section (figs. 2-D and 4). This hydraulic form was adopted for a detailed design in preference to the one employing plates and disks (figs. 2-B and 5) since it was believed that space limitations and mechanical complications made work on the latter form inadvisable.

In the preliminary stages a number of mechanical designs were considered. In one a tie rod held together a spacer section and a separate cutter-tube housing made of thin sheet brass soldered on a framework. Welded body and spacer sections were also considered, but sketches and calculations indicated that the instrument would be too heavy.

Sampler Model 3530-CM[5] Figure 13

The construction method chosen for the final design employs a one-piece housing of cast aluminum alloy. The use of aluminum-alloy castings for practically all the structural parts increases the strength, eliminates a number of parts, and reduces the weight to about 9 pounds per unit. The spacer and body sections are made as a unit one foot in height. These can be stacked one above another and bolted together to form a multiple sampler. The division between units is made at a large cross-section in order that the bolted joints can be made as strong as the spacer sections. Eliminating the rod from the center of the sampling space resulted in an arrangement consisting of a cylindrical cutter tube supported in front of a rigid structure. A streamlined section is the logical housing for such an arrangement since reduction of stream drag is important.

The cutter-tube assembly is made so that the spring energy is dissipated at the top seal which comes into action only at the end of the stroke. This makes it possible to employ a sharp

[5]Code to model numbers: 3530-CM = 3.5 in. bore; 3.0 in. stroke; C refers to the arrangement of cutter tube, spring, and seals; M is for multiple sampler.

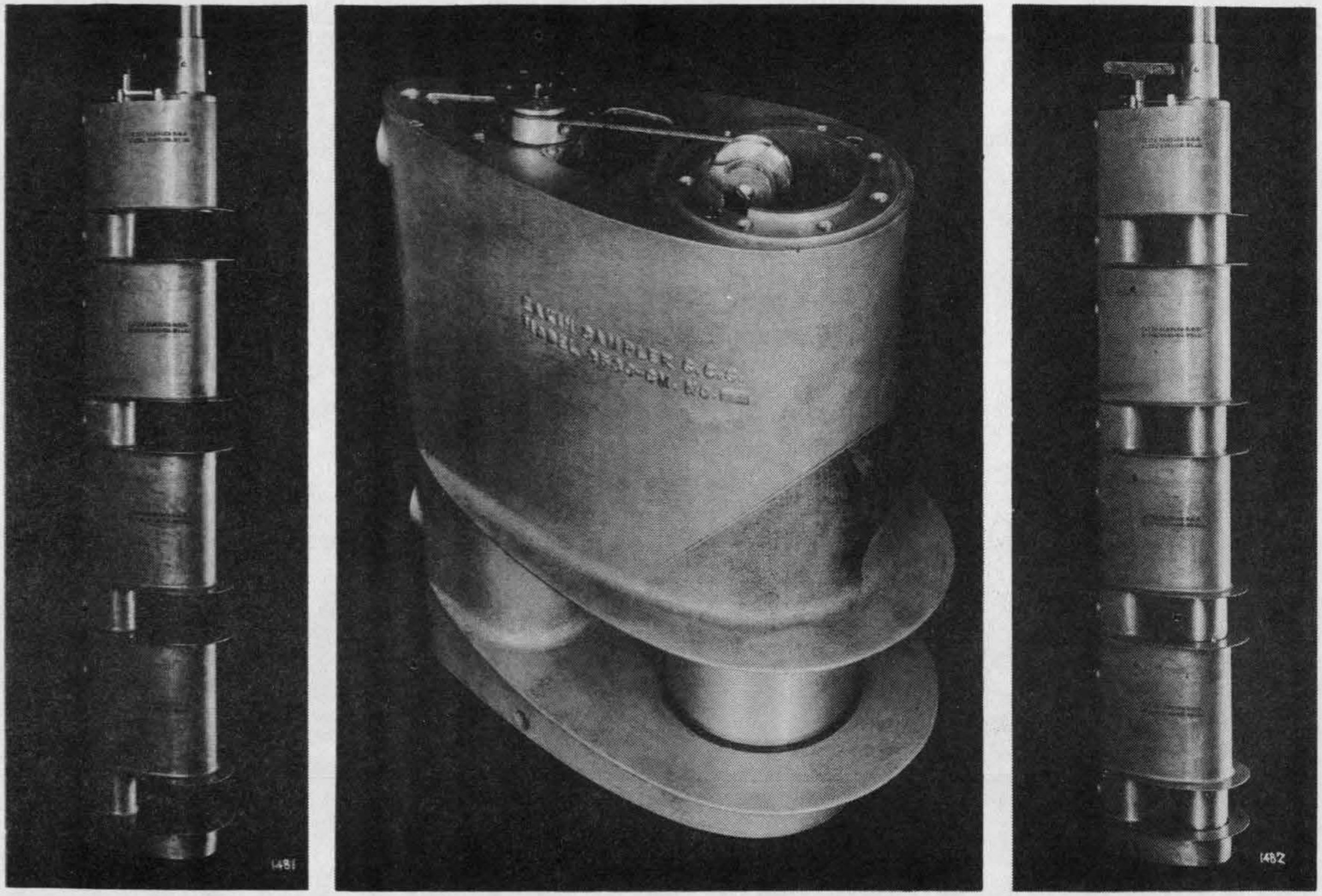


Figure 13.--A detailed view of a unit of the Eakin suspended-load sampler model 3530-CM, and a stack of these units shown in the open and closed position.

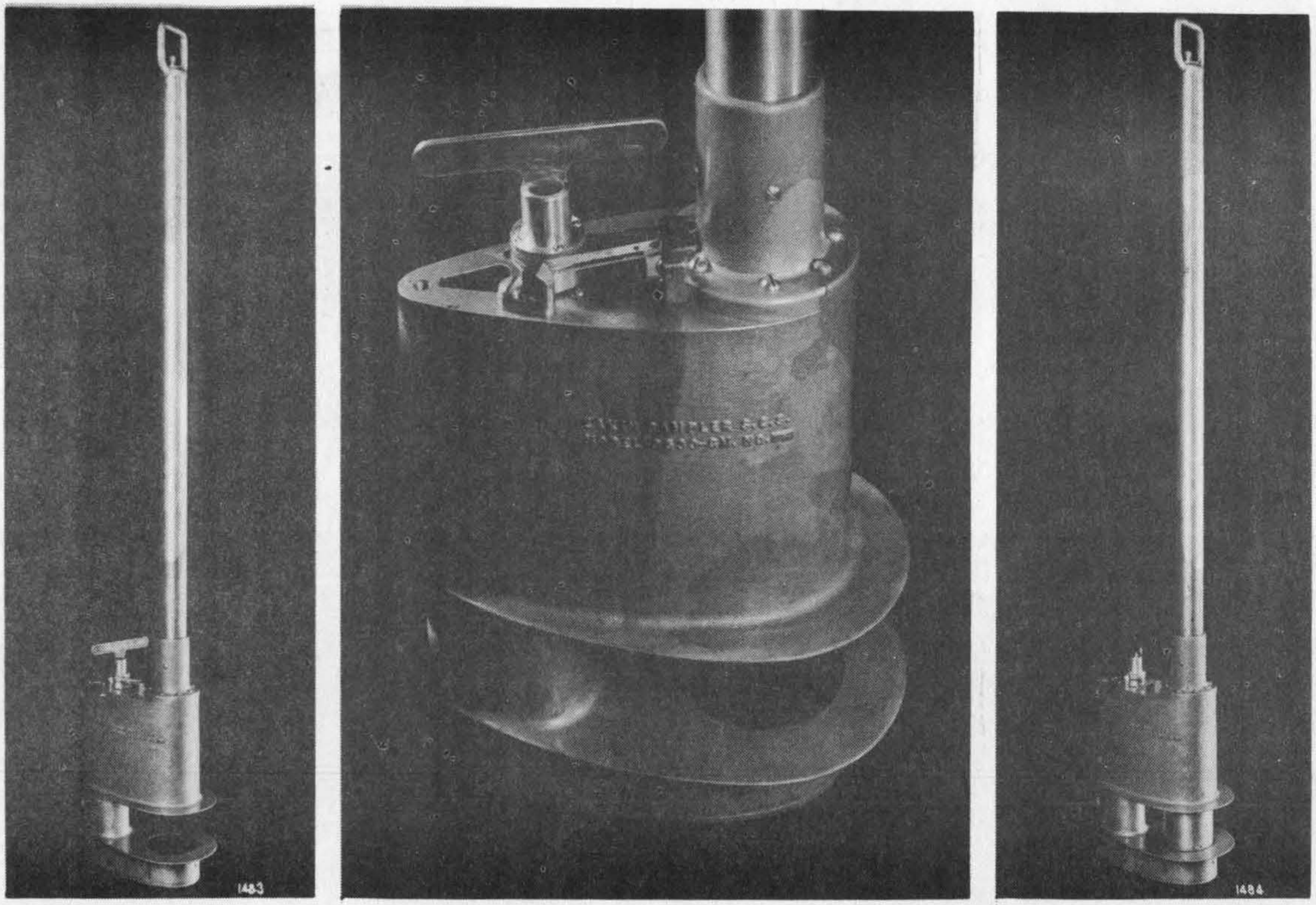


Figure 14.--A single unit of the Eakin sampler model 3530-CM with a bottom plate, rod adapter, and tripping mechanism.

cutter tube, a very flexible bottom seal, and a low-pressure resilient spring.

The cocking mechanism has been simplified by the use of a ball-bearing windlass, a pulley, and a flexible cable to lift the cutter tube (fig. 13, center). A relatively simple latch mechanism may be used since less than one revolution of the windlass is required to cock the sampler (fig. 14, center). Although the use of ball bearings under water is rather unconventional, it is believed that the simplification which they permit justifies their use. With sealed stainless-steel ball bearings, packed completely full with heavy waterproof grease, their success is quite probable.

Specifications and working drawings for the Eakin sampler model 3530-CM are contained in appendix I. Five units of this sampler were constructed and the patterns and drilling templates are available for use when additional instruments are needed. A bottom plate, rod adapter, and tripping mechanism were constructed as shown in figure 14 and used to test the sampler for proper operation in heavy concentrations of fine sand. It is believed that these end sections will be useful for taking samples from low bridges or for sampling shallow streams by wading. Handling facilities should be designed to suit the sampling station when more than two units are stacked together, when the water is deep or the velocities high, and when high structures traverse the stream.

PART FOUR--THE DESIGN OF SINGLE-UNIT EAKIN CUTTER-TYPE SUSPENDED-LOAD SAMPLERS

Introduction

Stream-line plots for designs that have a cylindrical body and a rod through the sampling space are represented by figures 6 and 7. The first, which has thin circular plates to separate flow around the cutter tube from flow through the sampling space, produces very little disturbance. When these plates are omitted and a thin disk is used for the bottom seal (fig. 7), the flow is quite uniform at the bottom of the sampling space but is curved at the top. This form was chosen for the line-suspended samplers presented herein because of its greater simplicity and because a line-suspended sampler often assumes an angle to the flow and consequently the advantages of the plates cannot be fully realized. However, with bad orientation, flow through any Eakin cutter-type sampler is not impaired to the extent that it would be by other types which have a sampling space less accessible to the flow.

Eakin Sampler Model 4040-A

An experimental model of a single-unit sampler was constructed of brass and is shown in figure 15-A. The cutter tube is assembled around a central guide rod which supports the bottom-sealing disk and terminates in a tang which fits standard current-meter

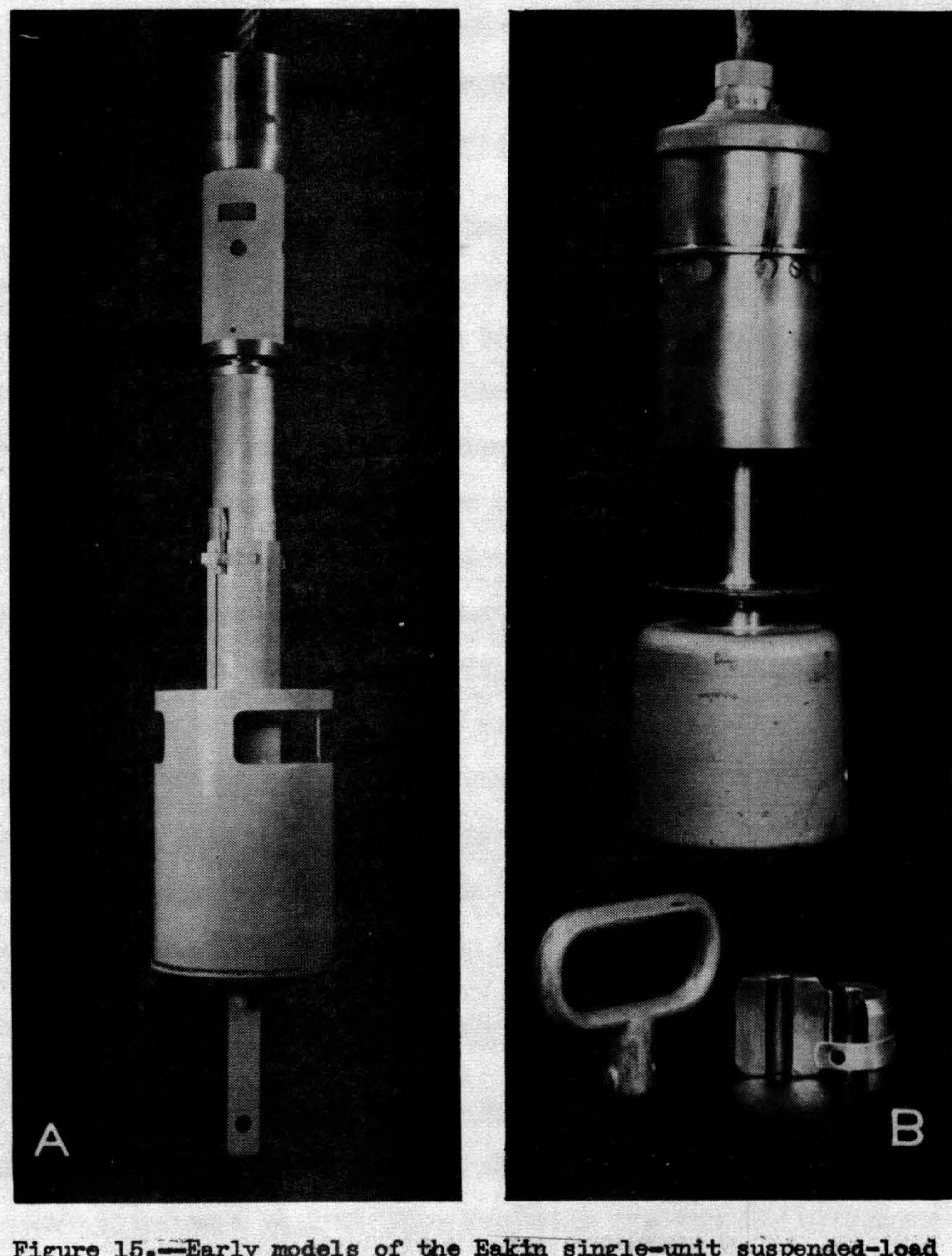


Figure 15.—Early models of the Eakin single-unit suspended-load sampler. A, model 4040-A; B, model 3530-B.

weights. Hooks, which hold the cutter tube in the cocked position, are attached to the slotted outside portion of a telescoping spring housing which is connected to the cutter tube by means of a perforated plate. A locking-and-tripping mechanism, which is also an anchor for the suspension rope, is arranged above the spring housing so that a tripping weight dropped down the rope will release the cutter tube and allow it to close against the bottom sealing disk under the action of the cutter-tube spring.

In an effort to provide tight seals, the first spring used exerted a pressure of 75 pounds when cocked and 25 pounds when closed. This spring was excessively stiff and caused the bottom plate to bend. It was replaced with a spring exerting 30 pounds when cocked and 20 pounds when closed, thus reducing the spring energy to half its former value. Even so, the repeated shock made it necessary to make the bottom seal supporting rod of stainless steel in order to prevent fracture.

It is interesting to note that the spring tension is the essential factor in determining shock. However, the energy available to produce shock is the spring energy minus the frictional losses incurred during the downward stroke of the cutter tube. Such losses increase when the weight of the cutter tube is decreased because a lighter tube will trip at a higher velocity and thus produce greater fluid friction. It is seen, therefore, that making the cutter tube lighter may decrease the shock load for tripping in water;

but in air, where there is less fluid friction, the difference will be very small. If the body of the sampler is made light it can be accelerated slightly under the impact of the cutter tube and thus further reduce the stress in the bottom disk and its supporting rod.

Experience gained in constructing model 4040-A made it appear desirable:

1. To reduce the spring pressure.
2. To improve the seals to insure proper functioning under reduced pressure.
3. To devise means for absorbing energy stored in the moving cutter tube without overstressing any of the parts.
4. To change the spider arrangement at the top of the cutter tube so as to prevent water from squirting into the air when the sampler is tripped near the water surface.
5. To avoid silver soldering which anneals the brass.

A design was prepared, therefore, using the same general arrangement of parts but avoiding many of the defects of the first sampler. Further study, however, indicated the desirability of a complete redesign which resulted in further improvements which were incorporated in model 3530-B.

Eakin Sampler Model 3530-B

Nine samplers have been constructed according to the drawings and specifications in appendix II. The assembly, as shown in figure 15-B, cost $80.00 when ordered in lots of four with patterns furnished to the contractor. The following improvements are incorporated in this model:

1. The spring has a small variation in pressure over the working range and a pressure of about 9 pounds when closed, thus reducing the energy to be dissipated when the sampler is tripped.
2. Better seals permit the use of the reduced spring pressure.
3. Silver soldering is eliminated.
4. Aluminum-alloy castings simplify construction and reduce the stresses in the bottom seal supporting rod by making it possible for the body of the sampler to accelerate slightly under the impact of the cutter tube.
5. An easily detachable weight simplifies unloading the sample.
6. A split tripping weight is easily attached to the rope.

Description of the Eakin sampler model 3530-B.

The cutter tube of this sampler is made of 3 1/2-inch-O. D. thin-walled brass tubing and is guided by the outside of a housing which encloses a short spring, the large diameter of which reduces the variation in pressure. Slots in the housing are provided in order that the spring may be connected to the cutter tube. By telescoping the rope anchor and the locking-and-tripping mechanism inside the spring, only a small projection above the housing is required.

A very resilient spring was used, the working pressure being about 13 pounds when compressed and 9 pounds when expanded. The diameter of the spring in this model has been made as large as can be enclosed in the cutter tube because, for equal working pressures, the length of a spring may be decreased as its diameter is increased. The desired reduction in shock energy is accomplished primarily by a lowered spring pressure, and secondarily by the increased fluid friction loss resulting from the greater velocity of the lighter outer tube. In air the latter loss is small and a lightweight cutter tube has little effect on the shock loading, but a reduction in the weight of the sampler body reduces the shock stresses in both water and air by permitting the body to be more easily accelerated under the impact of the cutter tube. Because a bayonet mount connects the two, this slight movement of the sampler body can be made without accelerating the sinker weight. The weight can be quickly detached when the sampler is being emptied and a handle with a bayonet stud can be attached to the weight for convenient handling. At one gaging station the sampler was lowered into the stream by means of a derrick used for a current meter. A weight adapter (appendix II, dwg. No. L-243) was made in order that the regular current-meter weights might be used.

Sand-cast aluminum alloys were used to a large extent in order to increase the strength and reduce the weight and number of parts required. Since tripping the sampler imposed large shock loads on the rod supporting the bottom plate, and because field use would subject the sampler to impact against rocks and bridge structures, only those alloys high in both elongation and strength were considered. Alloy No. 220-T4 was selected for the body casting because, of all sand-cast aluminum alloys, it has the highest tensile strength, yield strength, elongation, and resistance to impact. A more generally used high-strength alloy (No. 356-T6) was specified for the remaining cast parts because of its excellent casting qualities.

To test the samplers for jamming, they were operated in a tank of water in which silt and fine sand were mixed. Adjustments were made in the clearance between the cutter tube and its guide so that the operation was satisfactory. In these tests it was found that the locking device on the tripping mechanism was seldom needed. Since the instrument should not be cocked until it is to be used, the lock may be eliminated without endangering the operator.

A dummy model, which had approximately the same weight and frontal area as sampler model 3530-B, was lowered into the Los Angeles River on March 4, 1938 during a flood period. In a velocity estimated to be 15 feet per second the suspension rope assumed an angle of 50° from vertical, making evident the need for greater weight in proportion to the frontal area when the sampler is used in swift streams. The heavier current-meter weights, attached by means of an adapter (appendix II, dwg. No. L-243), would be advantageous when high velocities are encountered. However, to realize fully the advantages of a streamlined weight, the sampler mechanism itself should be very compact and as heavy as possible.

Summary--model 3530-B.

1. This sampler is an acceptable rope-suspended, single-unit sampler in regard to its disturbance to the flow in the sampling space.
2. Its operation has been satisfactory in heavy concentrations of silt and fine sand.
3. The lock on the tripping mechanism was seldom used in actual practice and might be eliminated.
4. Tests for drift in high-velocity streams indicate that a new design should be developed which has reduced frontal area and increased weight.

Sampler Model 2724-D

New designs were prepared in order to develop a line-suspended single-unit sampler that would have minimum drift in rapid streams and be simpler in construction and more convenient to

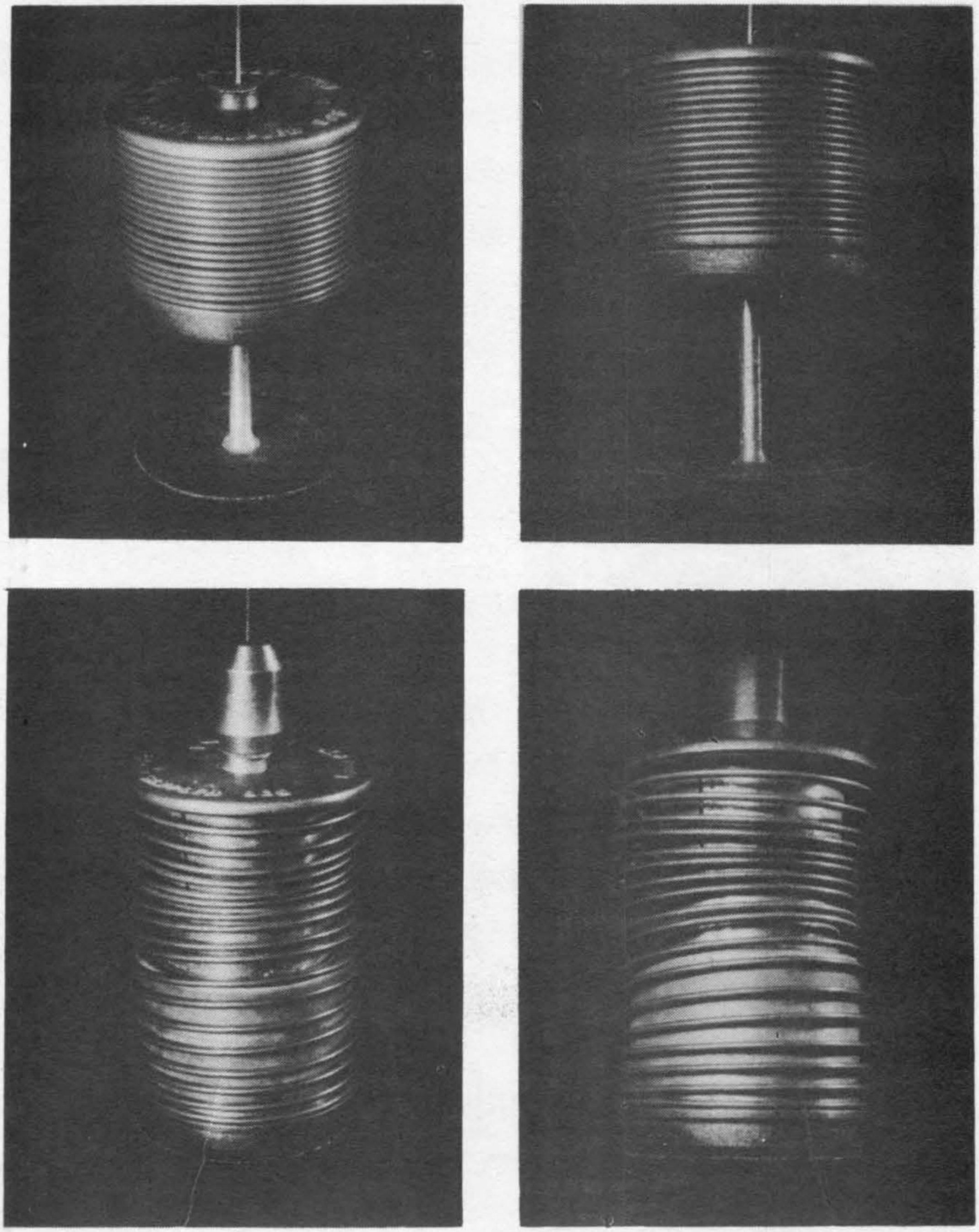


Figure 16.--The Eakin suspended-load sampler model 2724-D.

operate. This work culminated in a design, shown in figure 16 and in appendix III, which has the following features:

1. The frontal area is reduced by using a new arrangement of parts.
2. A further reduction in the size of the sampler is accomplished by decreasing the volume of the sample.
3. A small supporting cord is used in order to reduce the drag in deep water.
4. The weight in proportion to the frontal area is increased.
5. The spring is installed on the outside of the cutter tube, the lock is eliminated, and the latch and tripping mechanism are arranged so that a large portion of the interior of the body can be filled with lead.
6. A more effective sealing method is used and consequently a weak spring is satisfactory.

A preliminary design was based on a cutter-tube construction similar to that used in model 3530-CM, but it was found that greater compactness could be secured by putting the spring outside the active portion of a cutter tube that was only long enough to cover the sampling space. With this arrangement the body may extend just high enough to support the cutter tube in the cocked position. An examination of drawing No. 0-269 (appendix III) will reveal that any further material increase in compactness is impossible, since the top of the sampler is only about one-eighth of an inch above the top of the cutter tube and this is necessary as a spring retainer.

With a reduced sample volume, the instrument may be made small, compact, and more easily handled. Although this design is applicable to any sample volume, a small size is recommended so that a larger portion of the complete apparatus may be in the form of a streamlined lead weight. When high-velocity streams are being investigated, a weight adapter could be screwed on the bottom of the sampler in place of the cap nut. Additional weights are unnecessary in low-velocity streams, and the small size makes it possible to handle the instrument by some convenient means such as a swordfish line and reel. It should be noted that some reels will require a change in the gear ratio or the installation of a longer handle.

Occasions may arise when the suspended-load concentrations are so low that a large volume is needed for very accurate laboratory analysis. Usually, these concentrations will be accompanied by low velocities which decrease the difficulties of handling and make it easy to take a number of samples. The necessity for repeating the sampling operation is not a disadvantage because, when great accuracy is desired, it is essential to take several samples in order to average the fluctuations in concentration which are due to turbulence. Since all portable instantaneous samplers are too small to smooth out the effects of turbulence with a single grab, simplicity of design and convenience and reliability of operation should be given major consideration.

Of the latch mechanism considered, one made by slotting the body casting (appendix III) was the most compact and allowed the largest space for lead. The extent to which space is utilized is such that very little room is left inside the sampler body for air or water. Should the need arise, even greater movement of the latches could be obtained (within the elastic limit of the material) by making the slots deeper and at an angle which will result in a more uniform distribution of stresses.

In comparison with model 3530-B, the sealing arrangement has been greatly improved. When this instrument is tripped, the spring energy, which was absorbed by the bottom plate of the former models, is dissipated when a shoulder at the upper end of the cutter tube strikes a rubber gasket and presses against it to form the top seal. This makes it possible to use a sharp edge on the cutter tube, a very flexible bottom seal, and a spring pressure as low as 6 or 8 pounds. Although the sharp cutter tube strikes it first, this flexible bottom seal deflects sufficiently to allow complete sealing at the top.

Summary and recommendations--model 2724-D.

The line-suspended sampler shown in figure 16 and appendix III was designed for minimum draft in high-velocity streams. There was no tendency to jam when it was tested in heavy concentration of silt and fine sand, even when the load concentration was about 25 percent by volume. Although the fits were loose and the distance between the guides was short, this caused no trouble on closing because the top of the cutter tube was held in proper alignment while the spring pressure was applied at the bottom.

The slotted casting which forms the latches has been found very satisfactory. Without sacrificing reliability, greater simplicity can be achieved by replacing the thin metal tripping strap with short lengths of beaded lamp-socket chain. The chain could be attached very simply by drilling the top of the casting, thus eliminating four tapped holes and four screws. It is believed that this modification should be tried when additional units are built.

Summary and Recommendations on Single-unit Samplers

Tests indicate that flow through the single-unit cutter-type samplers is relatively undisturbed at the bottom of the sampling space but suffers some curvature at the top near the cylindrical cutter tube. It was not deemed advisable to attempt to remedy this with thin plates as was done with the multiple sampler, since line-suspended samplers often assume an angle to the flow and consequently the advantages of the plates cannot be fully realized.

After the construction of an experimental single-unit sampler in which mechanical difficulties appeared, model 3530-B was designed. Although this instrument (fig. 15-B) operated without mechanical difficulties, it suffered from excessive drift in high-velocity streams and its construction was believed to be more complicated than necessary.

Sampler model 2724-D (fig. 16) was designed to overcome these difficulties by reducing the size and frontal area and by increasing the weight. An examination of the drawing in appendix III will reveal that no further material increase in either compactness or weight can be obtained. The new arrangement of parts resulted in simplicity of construction and lower cost. Tests on this sampler have shown its operation to be satisfactory in high concentrations of suspended load. When additional single-unit line-suspended samplers are constructed, it is recommended that this model be adopted and that slight modifications in the tripping mechanism and the clearances be made in order to find the optimum dimensions for standardization.

PART FIVE--SAMPLER HANDLING FACILITIES

Since handling facilities vary from one location to another and depend more on the method of traversing the stream than on the type of sampler used, they are not considered in detail in this report. However, a few proposals seem in order; especially those dealing with apparatus directly connected to the samplers.

Multiple-unit Sampler Rigging

The multiple-unit sampler is intended primarily for use in detailed investigations during which the instrument should be held rigidly in the stream by a mounting adapter which attaches to the top unit of the stack and permits the apparatus to be lifted along a vertical runway by means of a windlass.

The rod adapter shown in figure 14 should be satisfactory where one or two units are operated by hand from a low bridge. Perhaps a longer rod or additional units might be used if guy wires attached close to the sampler units oppose the force of the stream.

Although this apparatus is not designed to be suspended from a line, this may be desirable if the stream is deep and may be possible if the velocities are not high. Proper orientation might be maintained by attaching a heavy weight at the bottom, toward the rear; the supporting line at the top, toward the front; and fins to the bosses on the back of the sampler.

Suspension System for Sampler Model 3530-B

A rope large enough to be held by hand is supplied with model 3530-B. When larger weights are attached, a windlass may be necessary for lifting the apparatus. For one installation an adapter was made in order to use the windlass already provided for current meters.

Suspension System for Sampler Model 2724-D

The suspension line of this sampler has been made small in order to reduce drift in the stream. This instrument weighs only 6 1/2 pounds and, unless additional weights are used, may be operated without injuring the hands if gloves are worn. A better method would be to wind the line on a swordfish reel equipped with a friction brake and anti-reversing pawls. The smaller reels do not have sufficient mechanical advantage but often this may be remedied by reversing the gear ratio or by installing a longer handle. The reel could be attached to a short rod or mounting board which could be clamped to a bridge railing. The line might be arranged to pass over a pulley and counter combination arranged to read in feet.

By screwing an adapter flange to the top of the sampler, it may be mounted on a rod. When the instrument is used in this way, the lead may be removed from the interior to reduce its weight to about 2 1/2 pounds.

When a heavy weight is added to the bottom of the line-suspended sampler, the swordfish line should be replaced with stainless steel, stranded aircraft cable and a windlass of sufficient load-handling ability should be used. Weights should be detachable to facilitate unloading the sample. The sampler may be emptied and cocked simultaneously by pushing it through a 3 1/16-inch hole in the lid of a can which is 3 1/2 inches in diameter by 3 1/2 inches deep.

A few shakes as it is removed from the can will wash the silt off the bottom plate.

PART SIX—GENERAL SUMMARY OF RESULTS

Hydraulic Tests

A criterion for an ideal sampler, based upon an analysis of sediment-laden flow, has been adopted as a basis for tests which give an indication of the absolute accuracy of a sampler. It is believed that such tests are more significant than those which merely compare instruments of unknown accuracy. The criterion reqires that no portion of the sampled fluid shall be disturbed by changing its velocity in either magnitude or direction, in arriving at the point where it is taken. After studying the results of the tests, it was concluded that the Eakin cutter-type sampler could be made to approach more closely the conditions set forth in the criterion, and therefore, it was selected for the development of improved mechanical designs.

Multiple-unit Samplers

Model tests were used in designing a multi-unit sampler (fig. 13) which employs flow-correcting fins and is housed in an aluminum-alloy casting. The units are one foot high and arranged to stack, one above another.

Single-unit Samplers

After a preliminary experimental model had been tried, a rope-suspended single-unit sampler (fig. 15-B) was designed and it proved satisfactory in operation in heavy concentrations of silt and fine sand. Because the construction of this model was more complicated than necessary, and the instrument suffered from excessive drift in high-velocity streams, model 2724-D, (fig. 16) was designed to overcome these difficulties. It is recommended that this design be adopted when additional samplers are constructed.

General Information

Mounting and handling facilities have not been dealt with in detail, but pertinent suggestions are found in part five of this report.

Complete drawings and specifications for the multiple-unit sampler and two of the single unit-samplers are found in appendices I, II, and III. A number of templates used in their construction and patterns for all castings are in storage at the U. S. D. A., Soil Conservation Service, Cooperative Laboratory, California Institute of Technology, Pasadena, California.

Acknowledgments

Prof. Robert T. Knapp of the California Institute of Technology was responsible for the initiation of this research and many of the basic ideas used in the hydraulic tests were suggested by him. The work was carried out with the aid of the Works Projects Administration Official Project No. 65-2-07-58, Work Project No. PS-11496.

APPENDIX I

DRAWINGS AND SPECIFICATIONS FOR MULTIPLE-UNIT[1] EAKIN SAMPLER MODEL 3530-CM

[1]Since handling facilities should be designed to suit the sampling station, the necessary attachments to the bottom and top units are not covered by these drawings and specifications. A bottom plate and tripping mechanism similar to that shown in figure 14 would be satisfactory in most cases, but a mount heavier than the rod adapter will be required to hold a multiple-unit stack in a high-velocity stream.

Specifications for Multiple-unit Eakin Sampler Model 3530-CM

The suspended-load sampler covered by these specifications shall be furnished ready for operation with all machining and fitting completed. Each of the sampler units in the stack shall conform to drawings No. P-248 revised 2-9-39 and 9-29-39, No. P-249 revised 4-4-39 and 9-29-39, No. P-250 revised 9-29-39, and No. P-251 revised 9-29-39. The number of units assembled in the stack and the type of end attachments used shall conform to instructions and specifications not herein provided.

Service requirements.

The apparatus specified herein is to be used to take samples of silt-laden water from various points in a stream for the purpose of determining the suspended-load concentration. Samples are to be obtained by rigidly supporting the apparatus in the stream by means of an attachment bolted to the top unit of the stack and then closing the sampler by releasing the cable windlass (part No. 22, dwg. No. P-248) in order to allow the cutter tube (2) to close against the bottom sealing disk (16) under the action of the cutter-tube spring (8).

Field use under adverse conditions makes it necessary that the parts be constructed of alloys possessing high strength and elongation. The section thickness shall be held to the closest possible limits to avoid excess weight or an impairment of strength.

Materials.

All castings (parts No. 1, 2, 3, and 19) shall be made of aluminum alloy No. 356-T6 or an alloy of similar composition and equally satisfactory machining qualities. The ultimate tensile strength shall be not less than 30,000 pounds per square inch and the elongation not less than 3 percent in 2 inches. A standard half-inch-diameter test specimen shall be supplied for each pour. The cutter-tube spring shall be made of spring phosphor bronze and all other materials shall conform to drawing No. P-248 revised 2-9-39 and 9-29-39.

Patterns and drilling templates.

The patterns, complete with all accessory parts, and the three drilling templates (dwgs. No. P-249-50) shall be delivered with the sampler and shall then become the property of the purchaser. The thin, projecting fins on the patterns for the body casting shall be made of sheet brass or duralumin in order to avoid warping or accidental breakage. All dowels and fixtures shall fit tightly to afford proper alignment of the parts and care must be taken to provide machining allowances only where indicated. The patterns shall, at the time of delivery, be in sufficiently good condition to permit obtaining at least 100 additional sets of dimensionally accurate castings.

Cutter-tube spring.

The cutter-tube spring shall consist of 20 turns of B. & S. 8-gage spring phosphor-bronze wire, wound to 3 7/16 inches outside diameter when compressed. The ends shall be ground only and the free length shall be 24 inches.

Finish.

All cast surfaces shall be cleared of waste metal and have rough surfaces and unintentional sharp corners removed. A smooth finish cut shall be required on all machined surfaces and the unmachined surfaces on the outside of the body casting shall be given a coat of aluminum paint.

Adjustments and tests.

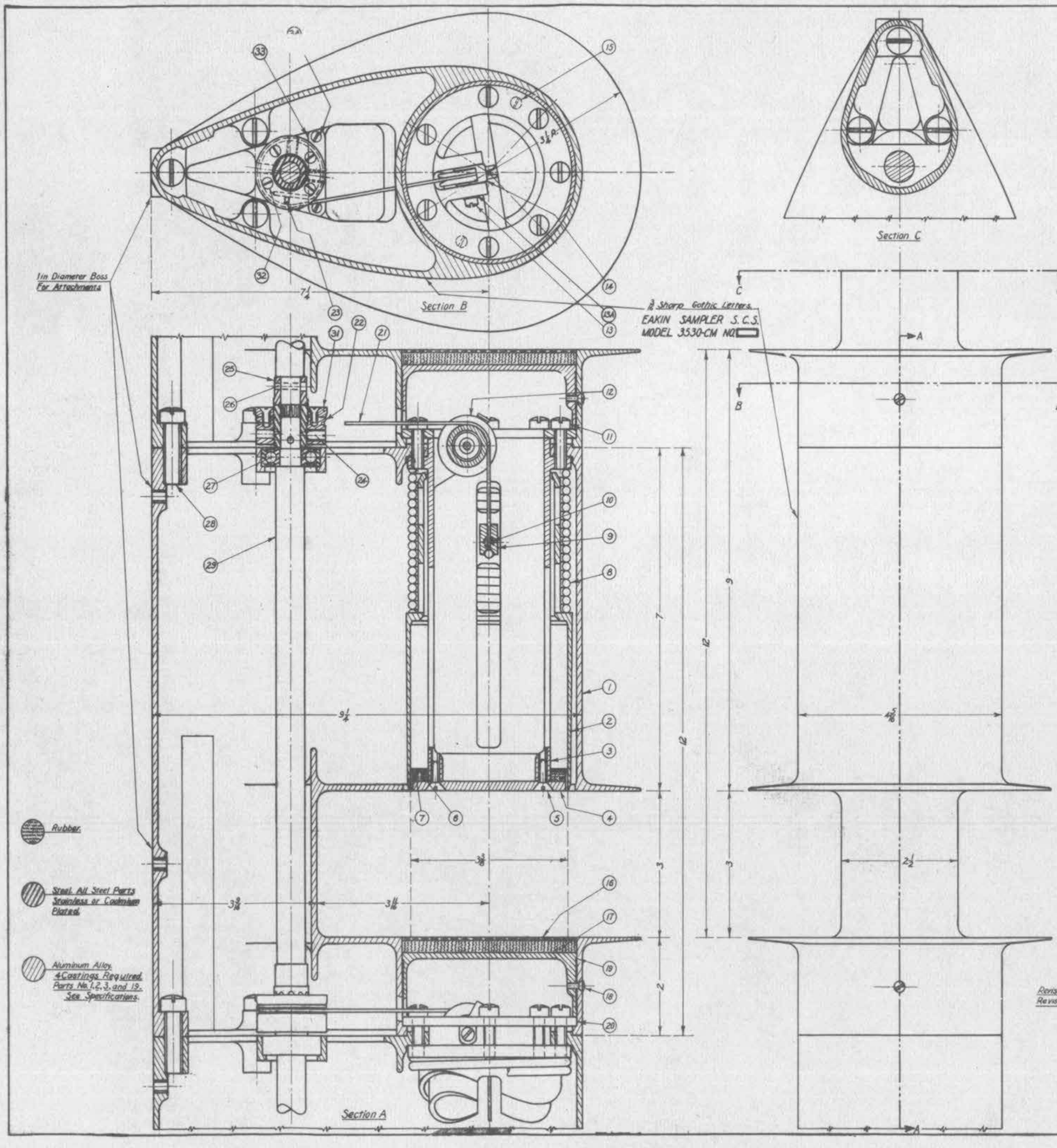
Windlass adjustments shall be made so that all the cutter tubes of a stack are fully cocked simultaneously. The top-sealing ring (7) shall be adjusted so that it does not apparently slow up the closing of the cutter tube. Since variations in the seals determine their effectiveness, they shall be adjusted so that not more than 50 percent of the sample will leak out in 10 minutes while the stack is supported horizontally.

Alternate Specifications--Model 3530-CM

If the purchaser is able to furnish the patterns and drilling templates, change the section that applies to these items to read as follows:

Patterns and drilling templates.

The patterns and the three drilling templates shall be furnished by the purchaser and shall be returned in good condition.



BILL OF MATERIALS

Part No.	Name of Part	No. Reqd.	Remarks
1	Body Casting	1	Detail Dwg. No. P249. See Alloy Specifications.
2	Cutter-Tube Casting	1	" " " P250. " " "
3	Cutter-Guide Casting	1	" " " " " " "
4	Top Sealing Plate	1	" " " " $\frac{3}{16}$ in. 17-ST Duralumin.
5	Top Plate Screws	8	$\frac{1}{2}$ in. #10-32 Flat Head 17-ST Duralumin.
6	Shock-Absorbing Ring	1	Detail Dwg. No. P250. $\frac{3}{16}$ Gum Rubber.
7	Top Sealing Ring	1	" " " " $\frac{1}{16}$ Duck-Insertion Rubber Sheet Packing. Garlock 19 or Equal.
8	Cutter-Tube Spring	1	See General Specifications.
9	Cutter Cross Bar	1	Detail Dwg. No. P-250. 17-ST Dural.
10	Cross-Bar Screws	2	$\frac{1}{2}$ in. #10-32 Flat Head 17-ST Duralumin.
11	Front Clamping Screws	7	$\frac{13}{16}$ in. $\frac{1}{4}$-20 Fillister Head 17-ST Duralumin.
12	Aircraft Control Pulley	1	Army-Navy Spec. No. 210-1A Dimensions with Double-Metal-Seal Stainless-Steel Ball Bearing No. K3A or No. 36-2Z. Pack Completely Full with Heavy Waterproof Grease.
13	Pulley-Axis Screw	1	1in. #10-32 Fil. or Round Head 17-ST Duralumin.
13A	Pulley-Screw Washer	1	Bronze Shakeproof Washer.
14	Cable-Guard Strap	1	#18 Ga. 17-St Duralumin See Dwg. No. P-250.
15	Cutter-Assembly Screw	2	$\frac{1}{2}$ in. #8-32 Oval Head 17-ST Duralumin.
16	Bottom Sealing Disk	1	$3\frac{3}{4}$ in. Dia. Material Same as Part No. 7.
17	Sponge-Rubber Disk	1	" " " $\frac{1}{4}$ in. Thick.
18	Retaining Screw	1	$\frac{1}{2}$ in. #8-32 Oval Head 17-ST Duralumin.
19	Bottom-Seal Support	1	Detail Dwg. No. P-251. See Alloy Specifications.
20	Clamping Ring	1	" " " " $\frac{3}{16}$ in. 17-ST Duralumin.
21	Cutter-Lifting Cable	1	$\frac{1}{16}$ in. Dia. 7x7 Strand Cable. 18-8 Stainless Steel. Upper End Soldered $\frac{1}{4}$ in. Lower End Knotted and Soldered. Length $11\frac{1}{2}$ in. Above Bottom of Cross Bar.
22	Cable Windlass	1	Detail Dwg. No. P-251. 17-ST Duralumin.
23	Cable-Anchoring Screw	1	$\frac{3}{16}$ in. #10-32 Cup-Pointed Set Screw. Cadmium Plated
24	Windlass Set Screw	2	$\frac{3}{8}$ in. $\frac{1}{4}$-20 " " " " " "
25	Multijaw Coupling	1	Boston No. FA75. Revised Dwg. P-251 " "
26	Coupling Pins	2	Stainless Steel. $\frac{1}{8}$ in. Dia. Through Shaft. See note, Dwg. No. P-251.
27	Cocking-Rod Bearing	1	12 mm. Double-Sealed Stainless-Steel Ball Bearing. Pack Completely Full with Heavy Waterproof Grease.
28	Rear Clamping Screw	3	$1\frac{1}{4}$ in. $\frac{3}{8}$-16 Fillister Head 17-St Duralumin.
29	Cocking Rod	1	Detail Dwg. No. P-251. $\frac{5}{8}$ in. Dia. 17-ST Duralumin.
30	Rubber Cement		For Attaching Sheet Rubber Seals. Goodrich Running Board Matting Cement.
31	Windlass Cap	1	$\frac{3}{16}$ in. 17-St Duralumin. See Detail Dwg. No. P-251.
32	Windlass-Cap Screw	4	$\frac{5}{16}$ in. #6-32 Oval Head 17-ST Duralumin.
33	Bearing-Retainer Strap	1	#26 Ga. 17 St Duralumin. See Detail Dwg. No. P-251.
34	Retainer-Strap Screw	2	$\frac{1}{4}$ in. #6-32 Round Head 17-St Duralumin.

ASSEMBLY INSTRUCTIONS

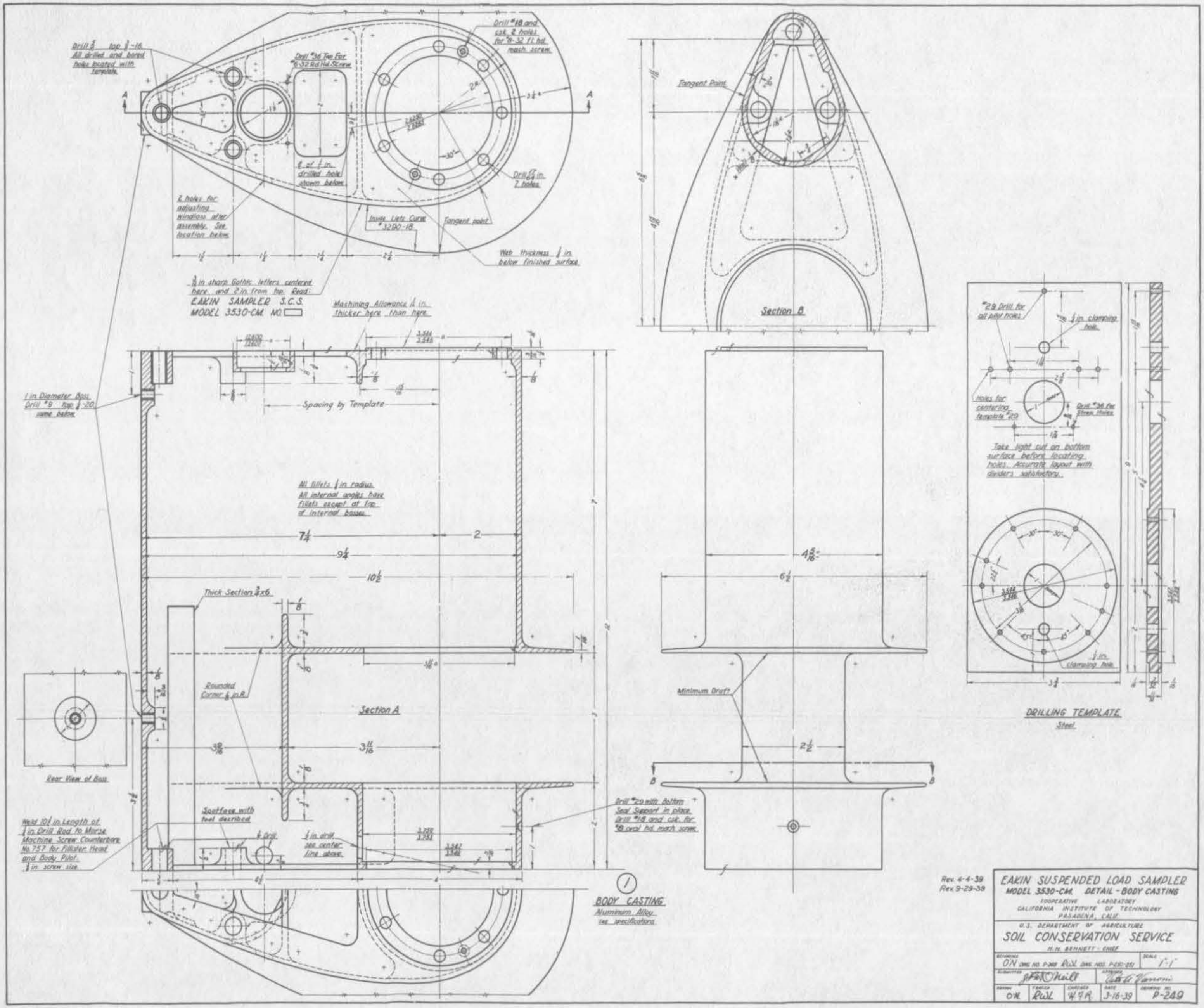
1. Mount Windlass Assembly in all Units.
2. Mount Cutter Tube Assembly in all Units.
3. Mount Clamping Ring in all Units.
4. Block up all Cutter Tubes.
5. Fasten Plate on bottom of Unit No.1 and insert Casting No. 19.
6. Fasten Cable (Unit No.1) to Windlass so that Cutter Tube is cocked when Windlass is rotated until Cable end touches to form loop.
7. Mark Cable and detach from Windlass.
8. Place Unit No.2 above Unit No.1.
9. Loop Cable of No.1 through Clamping Ring and hole in Body Casting of Unit No.2.
10. Fasten No.1 Cable to Windlass (same place as before).
11. Fasten Units together with front and rear Clamping Screws.
12. Insert Casting No 19 in Unit No.2
13. Repeat 6 for Unit No.2.
14. Adjust Windlass No.2 with Screw 24 so that rotation of Multijaw Coupling brings Units to cocked position in unison.
15. Repeat 7 to 14 until Stack is completed.

Revised 2-9-39
Revised 9-29-39

EAKIN SUSPENDED LOAD SAMPLER
MODEL 3530-CM. ASSEMBLY-ONE UNIT.
COOPERATIVE LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA - CALIF.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT - CHIEF

REFERENCE				SCALE
Dwg. No. P-249-250-251				1" = 1"
SUBMITTED: J.H. O'Neill		APPROVED: Vito A. Vanoni		
DRAWN: O.N.	TRACED: O.N.	CHECKED: H.T.R.	DATE: 8-1-38	DWG. NO. P-248


Drill 3/8 tap 7/16-16. All drilled and bored holes located with template.
Drill #36 Tap For 6-32 Rd.Hd.Screw
Drill #18 and csk. 2 holes for #8-32 fl. hd. mach. screw.
Drill 17/64 in. 7 holes
2 holes for adjusting windows after assembly. See location below.
¢ of 1/4 in. drilled hole shown below.
Inside Lists Curve 3200-18
Tangent point
Web thickness 1/8 in. below finished surface
3/8 in sharp Gothic letters centered here, and 2 in. from top. Read:
EAKIN SAMPLER S.C.S. MODEL 3530-CM. NO.
Machining Allowance 1/8 in. Thicker here than here.
Spacing by Template
1 in. Diameter Boss. Drill #9 tap 1/4-20 same below
All fillets 1/8 in radius. All internal angles have fillets except at top of internal bosses.
Thick Section 3/4x6
Rounded Corner 1/8 in.R.
Section A
Rear View of Boss
Spotface with tool described
Weld 10 1/2 in. Length of 1/4 in. Drill Rod to Morse Machine Screw Counterbore No.757 for Fillister Head and Body Pilot. 3/8 in. screw size.
1/4 in. drill see center line above.
Tangent Point
Section B
Minimum Draft
Drill #29 with Bottom Seal Support in place. Drill #18 and csk. for #8 oval hd. mach. screw.
#29 Drill for all pilot holes.
1/4 in. clamping hole.
Holes for centering template #29
Drill #36 for Strap Holes
Take light cut on bottom surface before locating holes. Accurate layout with dividers satisfactory.
1/4 in. clamping hole.
DRILLING TEMPLATE
Steel
1
BODY CASTING
Aluminum Alloy
see specifications
Rev. 4-4-39
Rev. 9-29-39
EAKIN SUSPENDED LOAD SAMPLER
MODEL 3530-CM. DETAIL - BODY CASTING
COOPERATIVE LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIF.
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT - CHIEF
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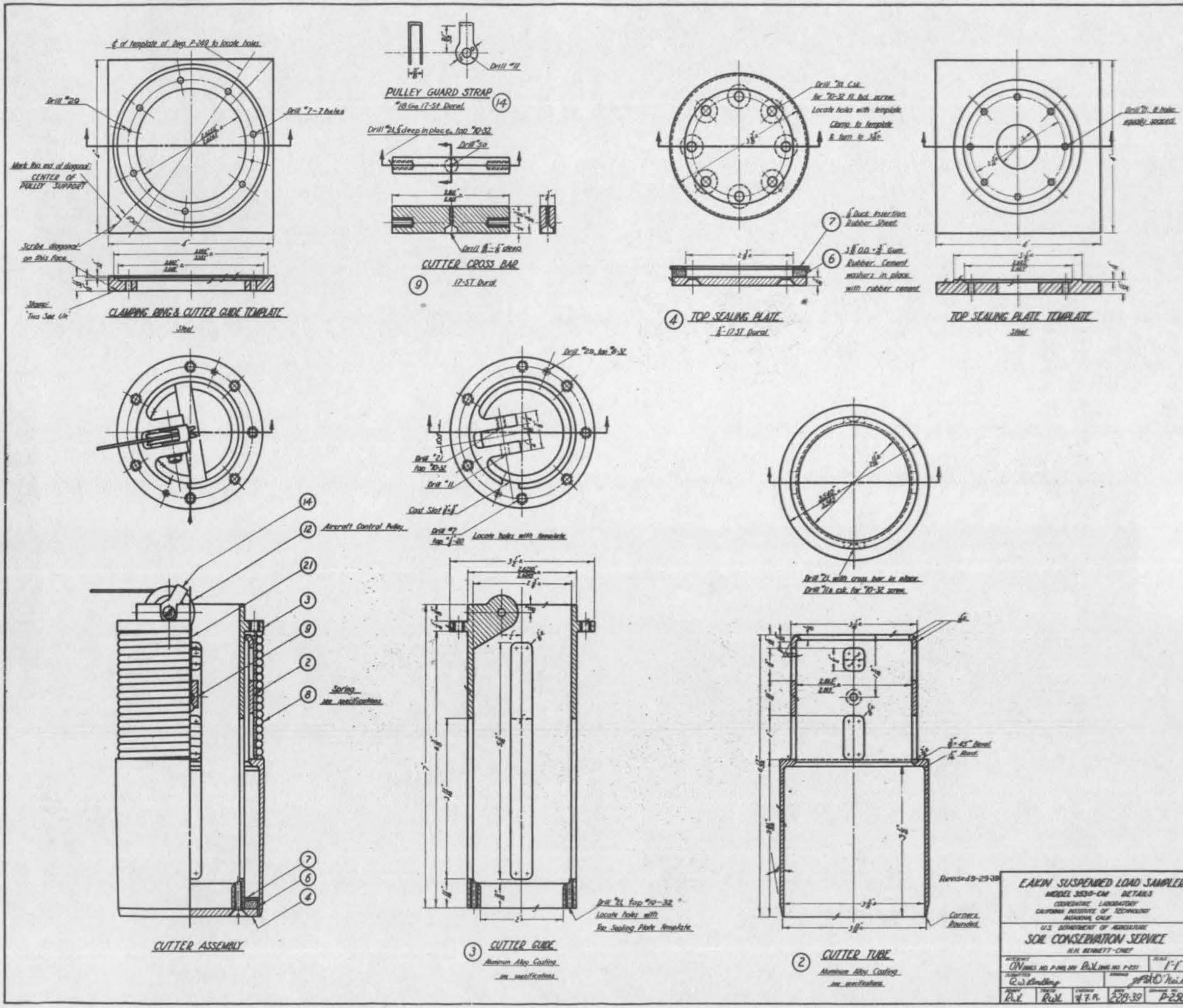
P-249
3-16-39



CLAMPING RING & CUTTER GUIDE TEMPLATE
Steel
Drill #29
Drill #7-7 holes
Mark this end of diagonal: CENTER OF PULLEY SUPPORT
Scribe diagonal on this face
Stamp: This Side Up
PULLEY GUARD STRAP
14
#18 Ga. 17-ST Dural
Drill #11
Drill #30
CUTTER CROSS BAR
9
17-ST Dural
4
TOP SEALING PLATE
7
Duck Insertion Rubber Sheet
6
Rubber Cement washers in place with rubber cement
Locate holes with template
Clamp to template & turn to
TOP SEALING PLATE TEMPLATE
Steel
Drill #11
Cast Slot
Locate holes with template
12
Aircraft Control Pulley
21
3
2
8
Spring see specifications
CUTTER ASSEMBLY
3
CUTTER GUIDE
Aluminum Alloy Casting see specifications
Locate holes with Top Sealing Plate template
2
CUTTER TUBE
Aluminum Alloy Casting see specifications
Corners Rounded
Revised 9-29-39
EAKIN SUSPENDED LOAD SAMPLER
MODEL 3530-CM DETAILS
COOPERATIVE LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIF.
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT-CHIEF
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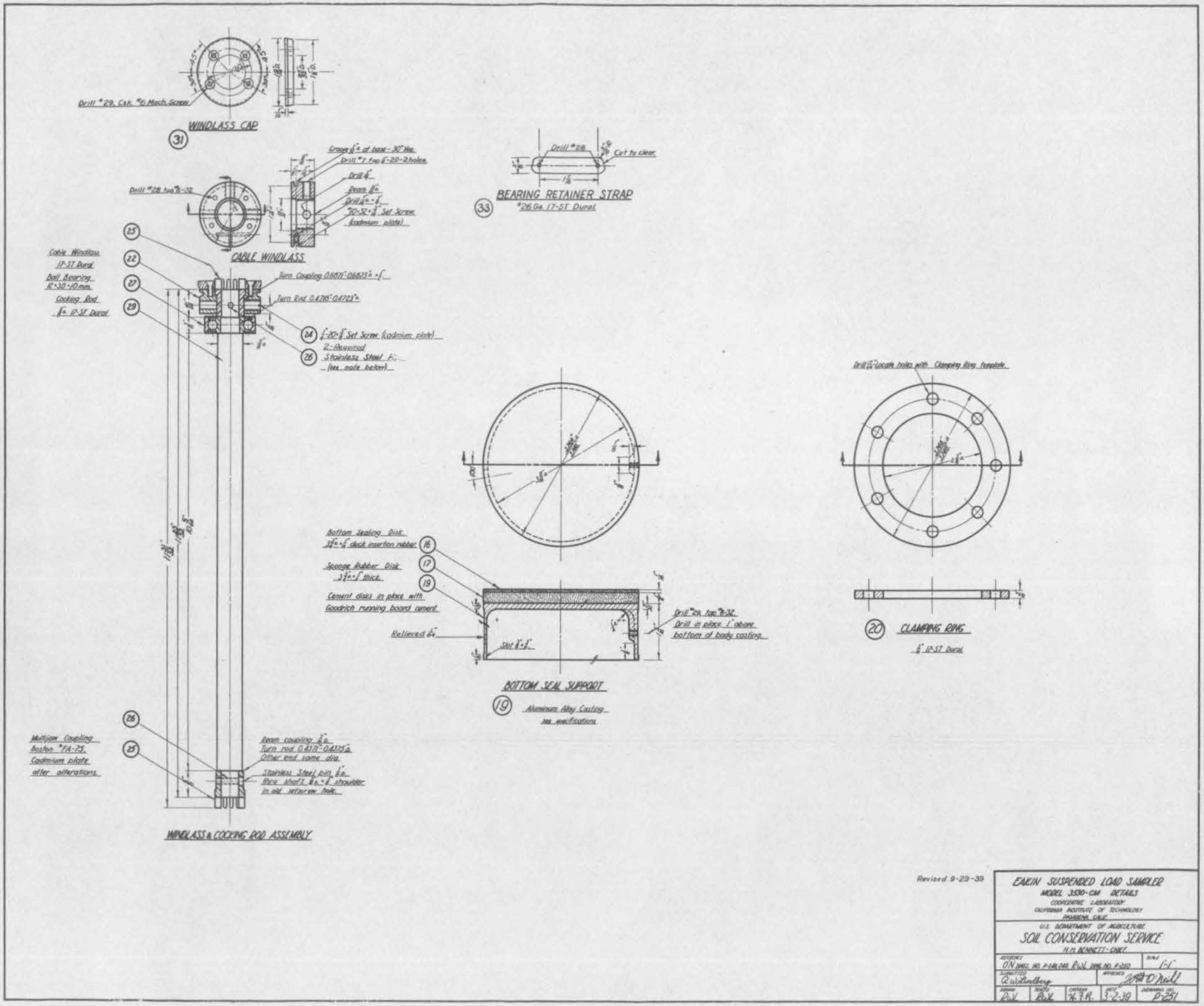

WINDLASS CAP
31
Drill #29, Csk. #6 Mach. Screw
CABLE WINDLASS
BEARING RETAINER STRAP
33
#26 Ga. 17-ST Dural
Drill #28
Cut to clear
Cable Windlass
17-ST Dural
Ball Bearing
Cocking Rod
2-Required
BOTTOM SEAL SUPPORT
19
Aluminum Alloy Casting
see specifications
Bottom Sealing Disk
Sponge Rubber Disk
Cement disks in place with
Goodrich running board cement
Drill in place, 1" above
bottom of body casting.
CLAMPING RING
20
Multijaw Coupling
Boston #FA-25.
Cadmium plate
after alterations.
WINDLASS & COCKING ROD ASSEMBLY
Revised 9-29-39
EAKIN SUSPENDED LOAD SAMPLER
MODEL 3530-CM DETAILS
COOPERATIVE LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIF.
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT - CHIEF
3-2-39
P-251

APPENDIX II

DRAWINGS AND SPECIFICATIONS FOR

EAKIN SAMPLER MODEL 3530-B

Specifications for Eakin Sampler Model 3530-B

The suspended-load sampler covered by these specifications shall be furnished assembled and ready for operation with all machining and fitting operations completed. It shall conform to drawing No. P-233 revised 1-28-38, 2-15-38, 5-17-38, and 6-1-38 which forms a part of these specifications.

Service requirements.

The sampler specified herein is to be used to take samples of silt-laden water from any desired point in a stream for the purpose of determining the suspended-load concentration. Samples are to be obtained by lowering the device to the desired point by means of a rope attached to the rope anchor (part No. 3, dwg. No. P-233) and then closing the sampler by dropping the tripping weight (9) down the rope. The tripping weight depresses the plunger (1) and releases the spider assembly (5) which, under the action of the cutter-tube spring, forces the cutter tube (6) to the closed position against the bottom-sealing disk. In order to avoid accidental tripping of the sampler when it is being handled out of water, the plunger is slotted to provide a safety lock. The sampler is to be used in the field under adverse conditions, therefore it shall be reliable in operation and convenient to handle. To make the apparatus easy to transport, the sampler mechanism shall be easily detachable from the bayonet mount in the lead weight so that the weight-carrying handle (8) can be inserted in its place. Since tripping the sampler imposes large shock loads on the structure, and because field use will subject the sampler to impact against rocks and bridge structures the high-strength aluminum alloys specified below shall be strictly adhered to.

Materials.

The body casting (4) shall be made of aluminum alloy No. 220-T4 or an alloy of similar composition and equally satisfactory machining qualities. The ultimate tensile strength shall be not less than 42,000 pounds per square inch and the elongation not less than 10 percent in 2 inches. A standard half-inch-diameter test specimen shall be supplied for each pour. All other castings (1, 2, 3, 5, and 8) shall be made of aluminum alloy No. 356-T6 or an alloy of similar composition and equally satisfactory machining qualities. The ultimate tensile strength shall be not less than 30,000 pounds per square inch and the elongation not less than 3 percent in 2 inches. A standard half-inch-diameter test specimen shall be supplied for each pour. The coil springs shall be of spring phosphor bronze and all other materials shall conform to drawing No. P-233.

Patterns.

The patterns, complete with all accessory parts, shall be delivered with the sampler and shall then become the property of the purchaser. The patterns shall, at the time of delivery, be in sufficiently good condition to permit obtaining at least a dozen dimensionally accurate sets of castings.

Coil springs.

The cutter-tube spring shall consist of 16 turns of B. & S. 7-gage spring phosphor-bronze wire, wound to 2 7/8 inches outside diameter. The free length shall be 18 3/4 inches with both ends squared and ground.

The plunger-lifting spring shall consist of 19 turns of B. & S. 18-gage spring phosphor-bronze wire, wound to 13/16 inch outside diameter. It shall have plain ends and a free length of 3 inches.

The plunger-depressing spring shall consist of 3 turns of B. & S. 10-gage spring phosphor-bronze wire, wound to 1 1/2 inches outside diameter. The free length shall be 19/32 inch with both ends squared and ground.

The bayonet spring shall consist of 6 turns of B. & S. 7-gage spring phosphor-bronze wire, wound to 1 1/16 inches outside diameter. The free length shall be 1 7/8 inches with both ends squared and ground.

Finish.

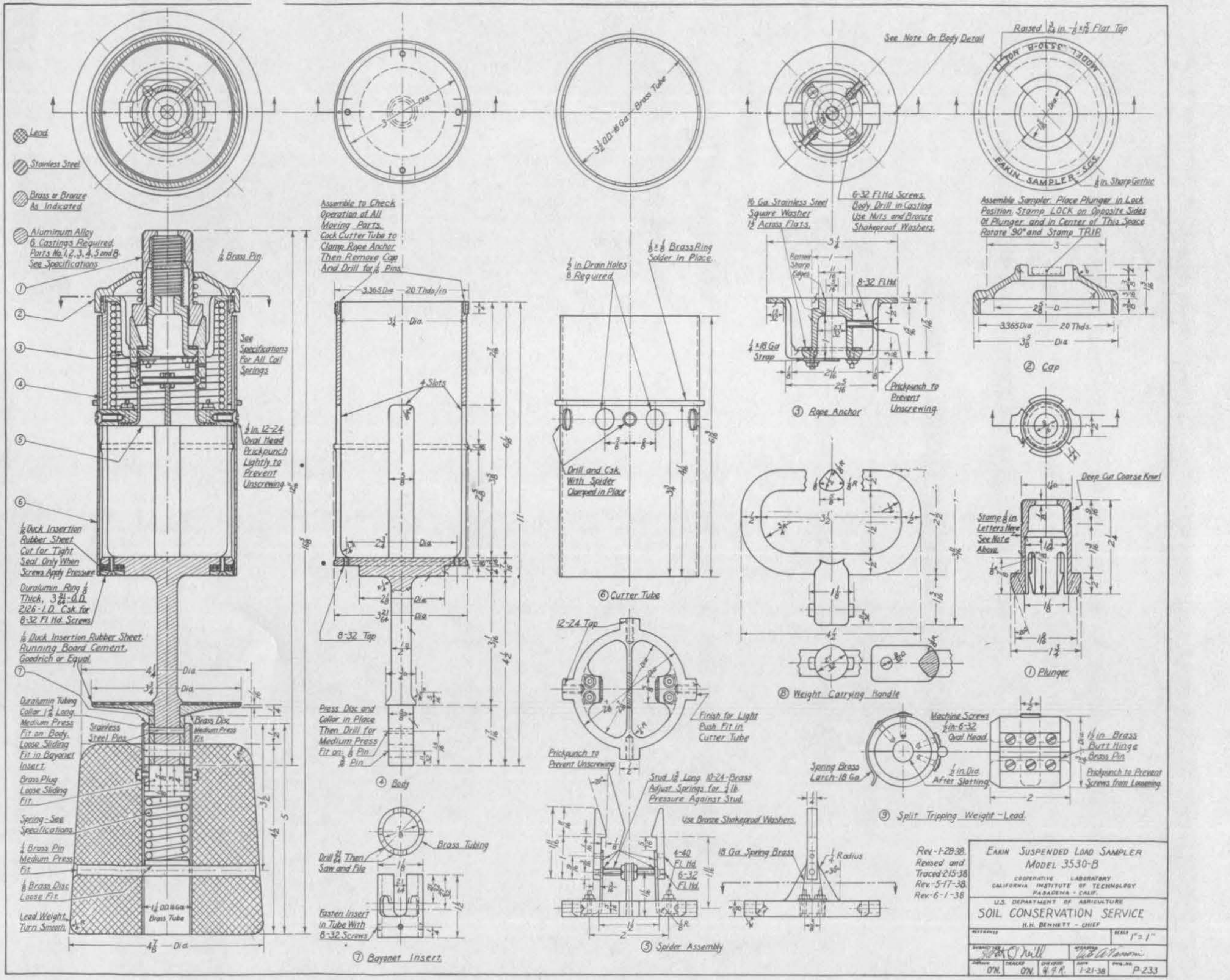
All cast surfaces shall be cleared of waste metal and have rough surfaces and unintentional sharp corners removed. The top of the cap (2) shall be supplied without scratches that uncover the bright metal or else it shall be given a coat of aluminum paint. A smooth-finish cut shall be required on all machined surfaces and the brass cutter tube shall be polished.

Alternate Specifications--Model 3530-B

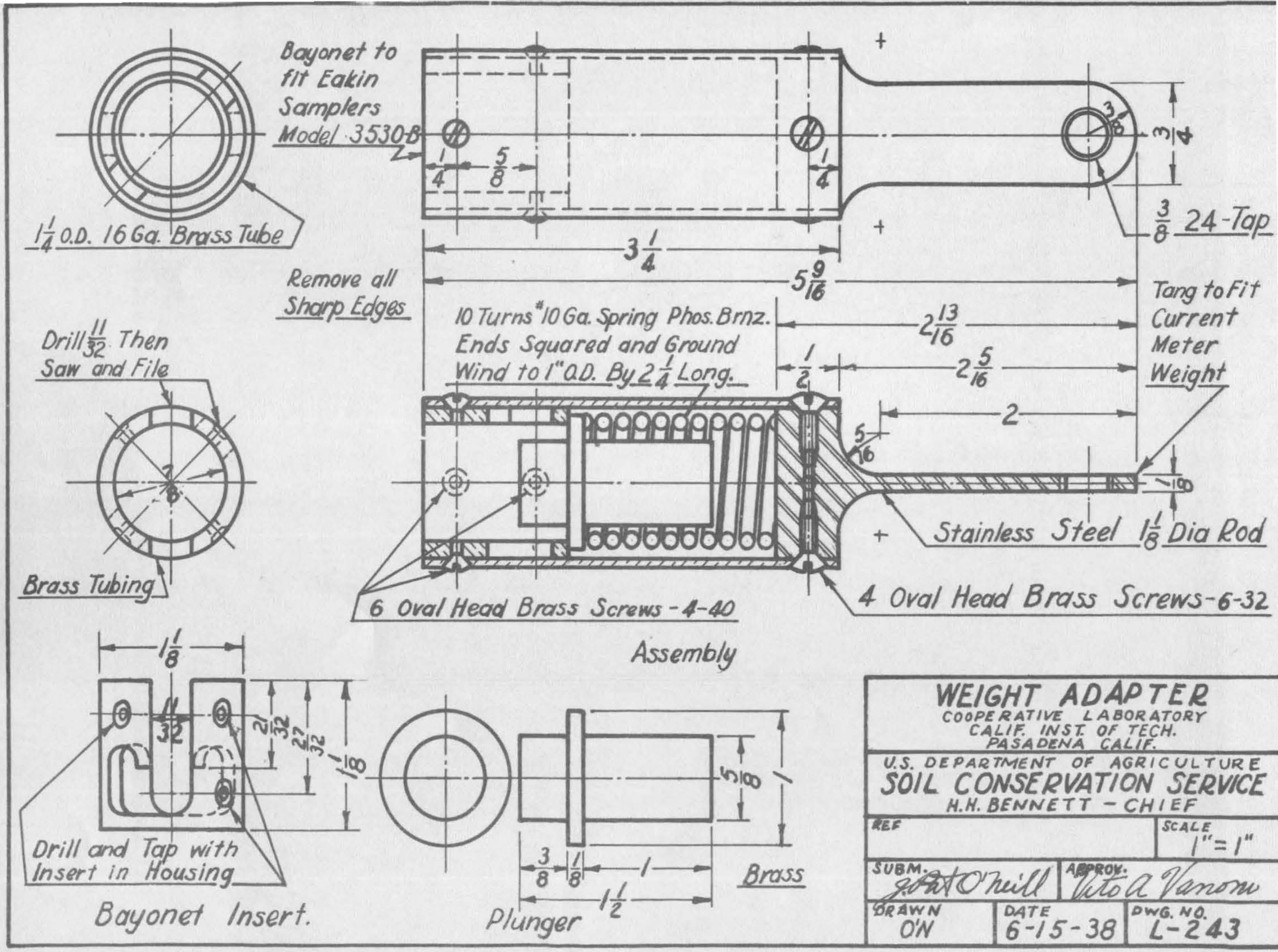
If the purchaser is able to furnish the patterns, change the section that applies to these items to read as follows:

Patterns.

The patterns shall be furnished by the purchaser and shall be returned in good condition.



Lead
Stainless Steel
Brass or Bronze As Indicated
Aluminum Alloy 6 Castings Required Parts No. 1, 2, 3, 4, 5 and 8. See Specifications
1/16 Brass Pin
See Specifications For All Coil Springs
1/4 in. 12-24 Oval Head Prickpunch Lightly to Prevent Unscrewing
1/8 Duck Insertion Rubber Sheet Cut for Tight Seal Only When Screws Apply Pressure
Duralumin Ring 1/8 Thick, 3 3/64 - O.D. 2126 - I.D. Csk. for 8-32 Fl. Hd. Screws
1/16 Duck Insertion Rubber Sheet. Running Board Cement. Goodrich or Equal.
Duralumin Tubing Collar 1 7/8 Long Medium Press Fit on Body. Loose Sliding Fit in Bayonet Insert.
Stainless Steel Pins
Brass Disc Medium Press Fit
Brass Plug Loose Sliding Fit.
Spring - See Specifications
1/8 Brass Pin Medium Press Fit
1/8 Brass Disc Loose Fit
Lead Weight. Turn Smooth
1 1/2 OD 16 Ga Brass Tube
Assemble to Check Operation at All Moving Parts. Cock Cutter Tube to Clamp Rope Anchor Then Remove Cap And Drill for 1/16 Pins.
3.365 Dia - 20 Thds/in
4 Slots
8-32 Tap
Press Disc and Collar in Place Then Drill for Medium Press Fit on 1/8 Pin
④ Body
Brass Tubing
Drill 21/64 Then Saw and File
Fasten Insert in Tube With 8-32 Screws
⑦ Bayonet Insert
3 1/2 OD 16 Ga. Brass Tube
1/2 in. Drain Holes 8 Required
1/8 x 1/8 Brass Ring Solder in Place.
Drill and Csk. With Spider Clamped in Place
⑥ Cutter Tube
12-24 Tap
Finish for Light Push Fit in Cutter Tube
Prickpunch to Prevent Unscrewing
Stud 1 3/8 Long 10-24 Brass Adjust Springs for 1/2 lb. Pressure Against Stud.
Use Bronze Shakeproof Washers.
4-40 Fl. Hd.
6-32 Fl. Hd.
18 Ga. Spring Brass
1/4 Radius
⑤ Spider Assembly
See Note On Body Detail
16 Ga. Stainless Steel Square Washer 1 1/2 Across Flats.
6-32 Fl. Hd. Screws. Body Drill in Casting Use Nuts and Bronze Shakeproof Washers.
Remove Sharp Edges
8-32 Fl. Hd.
1/4 x 18 Ga Strap
Prickpunch to Prevent Unscrewing
③ Rope Anchor
⑧ Weight Carrying Handle
Machine Screws 1/4 in. 6-32 Oval Head
Spring Brass Latch - 18 Ga.
1/2 in. Dia After Slotting
1 1/2 in. Brass Butt Hinge Brass Pin
Prickpunch to Prevent Screws from Loosening
⑨ Split Tripping Weight - Lead.
Raised 1/64 in. - 1/8 x 5/16 Flat Top
MODEL 3530-B LOCK
EAKIN SAMPLER - S.C.S.
1/8 in. Sharp Gothic
Assemble Sampler. Place Plunger in Lock Position. Stamp LOCK on Opposite Sides Of Plunger and in Center of This Space Rotate 90° and Stamp TRIP.
3.365 Dia - 20 Thds.
② Cap
Deep Cut Coarse Knurl
Stamp 1/8 in. Letters Here See Note Above
① Plunger
Rev.-1-28-38.
Revised and Traced 2-15-38.
Rev.-5-17-38.
Rev.-6-1-38
EAKIN SUSPENDED LOAD SAMPLER
MODEL 3530-B
COOPERATIVE LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA - CALIF.
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT - CHIEF
Scale 1" = 1"
O'N.
O'N.
W.F.R.
1-21-38
P-233


Bayonet to fit Eakin Samplers Model 3530-B
1 1/4 O.D. 16 Ga. Brass Tube
3/8
3/4
3/8 24-Tap
1/4
5/8
1/4
3 1/4
5 9/16
Remove all Sharp Edges
Tang to Fit Current Meter Weight
10 Turns #10 Ga. Spring Phos. Brnz. Ends Squared and Ground Wind to 1" O.D. By 2 1/4 Long.
2 13/16
1/2
2 5/16
2
5/16
1/10
Drill 11/32 Then Saw and File
7/8
Brass Tubing
Stainless Steel 1/8 Dia Rod
6 Oval Head Brass Screws - 4-40
4 Oval Head Brass Screws - 6-32
Assembly
1 1/8
11/32
21/32
27/32
1 1/8
5/8
1
Drill and Tap with Insert in Housing
3/8
1/8
1
1 1/2
Brass
Bayonet Insert.
Plunger
WEIGHT ADAPTER
COOPERATIVE LABORATORY
CALIF. INST. OF TECH.
PASADENA CALIF.
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT - CHIEF
REF
SCALE 1" = 1"
SUBM. J. Pat O'Neill
APPROV. Vito A Vanoni
DRAWN O'N
DATE 6-15-38
DWG. NO. L-243

APPENDIX III

DRAWINGS AND SPECIFICATIONS FOR

EAKIN SAMPLER MODEL 2724-D

Specifications for Eakin Sampler Model 2724-D

The suspended-load sampler covered by these specifications shall be furnished assembled and ready for operation with all machining and fitting operations completed. It shall conform to drawing No. 0-269 revised 9-4-39 and 3-12-40, which forms a part of these specifications.

Service requirements.

The sampler specified herein is to be used to take samples of silt-laden water from any desired point in a stream for the purpose of determining the suspended-load concentration. In use, the apparatus will be lowered to the desired point by means of the line (part No. 12, dwg. No. 0-269) and then it will be closed by dropping the tripping weight (20) down the line. This weight depresses the center of the tripping strap (9), thereby springing the latch on the body casting (1) to a position that allows the cutter tube (2) to close against the bottom seal (15) under the action of the cutter-tube spring (3).

The castings used in the instrument will be subjected to exposure to weather, severe jars and shock loads. During construction, parts of the body casting will be bent; and thereafter they will be repeatedly sprung back and forth in the normal operation of the instrument. This will require an alloy capable of a moderate amount of elongation and one possessing a high elastic limit.

Furthermore, the alloy must possess casting qualities permitting the casting of smooth surfaces on the cover (4) and the cutter tube.

Materials.

All castings (1, 2, 4, and 5) shall be made of aluminum bronze with an ultimate tensile strength not less than 70,000 pounds per square inch, a yield point not less than 35,000 pounds per square inch, and an elongation not less than 8 percent in 2 inches. A standard half-inch-diameter test specimen shall be supplied for each pour. The cutter-tube spring (3) shall be of spring phosphor bronze, and all other materials shall conform to drawing No. 0-269.

Patterns.

The patterns, complete with all accessory parts, shall be delivered with the sampler and shall then become the property of the purchaser. They shall, at the time of delivery, be in sufficiently good condition to permit obtaining at least 100 additional sets of dimensionally accurate castings.

Cutter-tube spring.

The cutter-tube spring shall consist of 19 turns of B. & S. 9-gage spring phosphor-bronze wire, wound to 3 1/8 inches outside diameter when compressed. The ends shall be ground only and the free length shall be 24 inches.

Finish.

The top of the cover and the outside of the cutter-tube casting shall be free from surface defects that mar the appearance or cause improper operation of the cutter-tube spring.

Adjustments and tests.

If it should be necessary, adjustments shall be made in the mounting of the tripping strap and in the latch tension so that blows (with the hand) against the side of the cutter tube will not trip the instrument and so that dropping the tripping weight about one foot (in air) will trip the sampler.

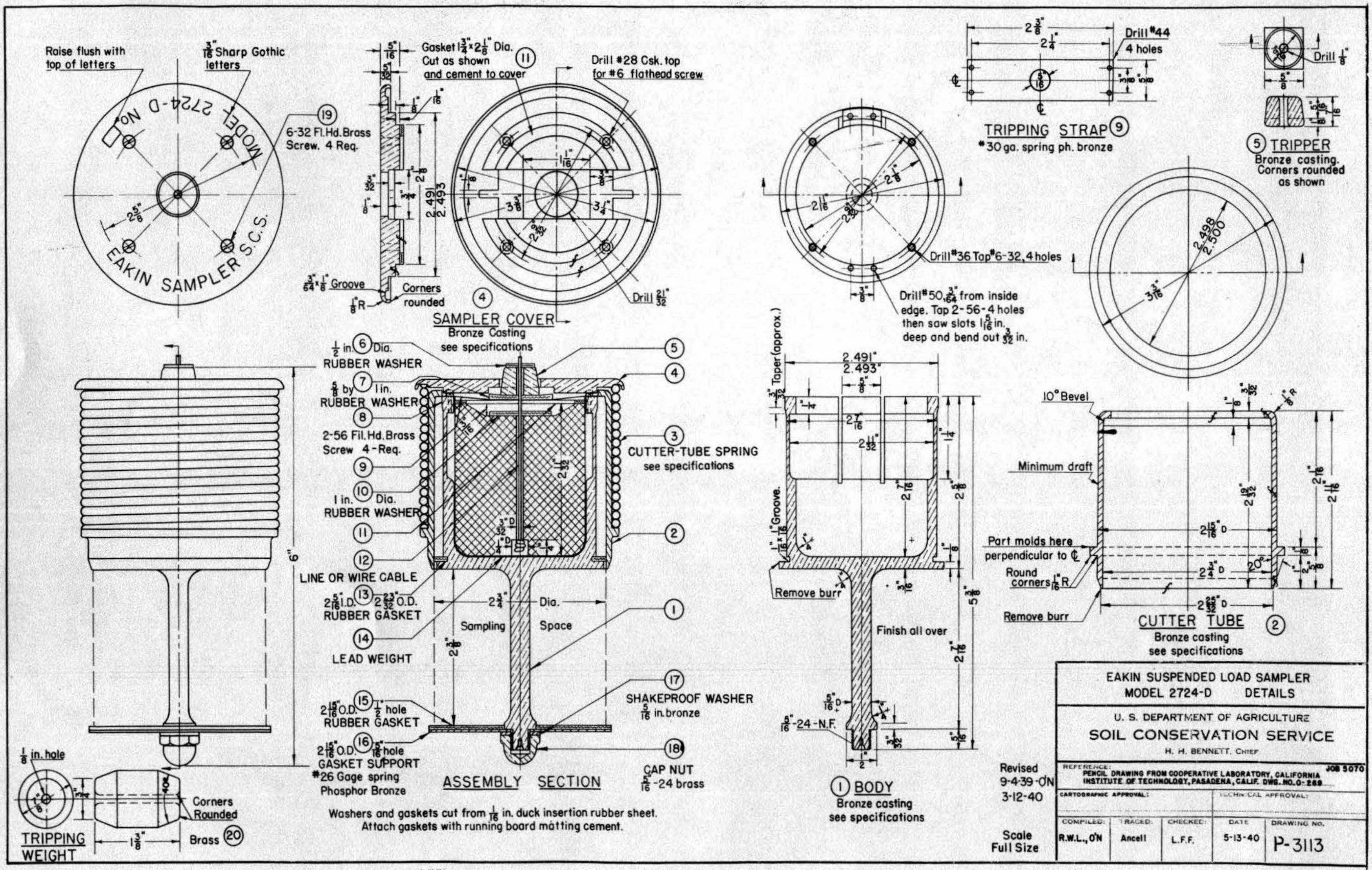
The seals shall be adjusted so that they do not apparently slow up the closing of the cutter tube and so that not more than 50 percent of the sample will leak out in 10 minutes while the sampler is supported horizontally.

Alternate Specifications—Model 2724-D

If the purchaser is able to furnish the patterns, change the section that applies to these items to read as follows:

Patterns.

The patterns shall be furnished by the purchaser and shall be returned in good condition.


Raise flush with top of letters
3/16" Sharp Gothic letters
MODEL 2724-D No.
EAKIN SAMPLER S.C.S.
6-32 Fl. Hd. Brass Screw. 4 Req.
Gasket 1 3/4" x 2 1/8" Dia. Cut as shown and cement to cover
Drill #28 Csk. top for #6 flathead screw
3/64" x 1/8" Groove
Corners rounded
Drill 21/32"
SAMPLER COVER
Bronze Casting
see specifications
1/2 in. Dia. RUBBER WASHER
5/8 by 1 in. RUBBER WASHER
2-56 Fil. Hd. Brass Screw 4-Req.
1 in. Dia. RUBBER WASHER
LINE OR WIRE CABLE
2 5/16" I.D. 2 23/32" O.D. RUBBER GASKET
LEAD WEIGHT
2 15/16" O.D. 1/2 hole RUBBER GASKET
2 15/16" O.D. GASKET SUPPORT
#26 Gage spring Phosphor Bronze
CUTTER-TUBE SPRING
see specifications
Sampling Space
SHAKEPROOF WASHER
5/16 in. bronze
CAP NUT
5/16"-24 brass
ASSEMBLY SECTION
1/8 in. hole
Corners Rounded
TRIPPING WEIGHT
Brass
Washers and gaskets cut from 1/16 in. duck insertion rubber sheet.
Attach gaskets with running board matting cement.
TRIPPING STRAP
#30 ga. spring ph. bronze
Drill #44
4 holes
TRIPPER
Bronze casting.
Corners rounded as shown
Drill 1/8"
Drill #36 Tap #6-32, 4 holes
Drill #50, 3/64" from inside edge. Tap 2-56 - 4 holes then saw slots 1 5/16 in. deep and bend out 3/32 in.
Taper (approx.)
Groove.
Remove burr
Finish all over
5/16"-24-N.F.
BODY
Bronze casting
see specifications
10° Bevel
Minimum draft
Part molds here perpendicular to ℄
Round corners 1/16" R.
Remove burr
CUTTER TUBE
Bronze casting
see specifications
EAKIN SUSPENDED LOAD SAMPLER
MODEL 2724-D DETAILS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF
REFERENCE: PENCIL DRAWING FROM COOPERATIVE LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF. DWG. NO. O-269
JOB 5070
CARTOGRAPHIC APPROVAL:
TECHNICAL APPROVAL:
COMPILED: R.W.L., O'N
TRACED: Ancell
CHECKED: L.F.F.
DATE 5-13-40
DRAWING NO. P-3113
Revised 9-4-39-O'N 3-12-40
Scale Full Size